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OUTLINES

OF

CHEMISTRY,

FOR

FAMILIES AND SCHOOLS.

BY

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PREFACE.

I WISH to teach you the OUTLINES OF CHEMISTRY, for it is an extremely interesting and important science.

If you are attentive to my instructions, you will soon learn many facts that will help you in your other studies, and also enable you to understand the conversation of your elders and superiors in knowledge; for subjects connected with Chemistry are very frequently mentioned in familiar discourse.

Perhaps you have heard or read something about the science of Chemistry, and think that it must be a very difficult study; this is only because you have not learned its principles, or outlines; and you might just as well think that a book must be very difficult, or a conversation very dull, because you do not know the alphabet and the forms of expression of the language in which the book is written, and the conversation conducted.

It is true that Chemistry becomes a difficult study if it be pursued into all its bearings and applications, because it includes an accurate examination of the nature and components of every production of the globe, and therefore requires a long and active life to be entirely devoted to the purpose; and even then, after all diligence and attention, a vast number of things would still remain unknown.

The most talented chemist, who devotes the whole of his time and attention to the study of Chemistry, does not know the full extent of the science—he is learning more and more every day. This laboriously acquired knowledge he does not keep to himself, but endeavours in every possible way to communicate to others, so that it may become generally useful in the advancement of the happiness and comfort of mankind.

But the mere Outlines of Chemistry you may easily learn, although you may never become a chemist; just the same as you may easily learn the outlines of astronomy, although you may never become an astronomer; and if you diligently and correctly gain this general knowledge, you will soon discover its interest and value, in whatever station of life it may be your lot to be placed.

I shall set you easy lessons; but remember that you must learn one lesson perfectly before you proceed to another; because I shall ask you questions about them all, from time to time, to see that you really do understand them; and if I find that you do not, you must go over them again and again; and thus, although your progress may be slow, it will have the advantage of being certain: and I hope that you will begin the study of Chemistry with willingness and pleasure.

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OUTLINES OF CHEMISTRY.

I. INTRODUCTION.

1 The ancients were acquainted with six metals, namely, Gold, Silver, Copper, Iron, Tin, and Lead.

2 Some learned men suppose that the ancients knew how to change Copper, Iron, Tin, and Lead, into Gold and Silver.

3 No proof exists that the ancients knew any such thing.

4 The first mention of an art by which Copper, Iron, Tin, and Lead might be changed into Gold and Silver, is found in the writings of Geber, a learned Arabian, who lived in the seventh century.

5 It was then imagined that the six metals known to the ancients were all naturally made of the same materials, and that such materials were pure or perfect in Gold and Silver, but impure or imperfect in Copper, Iron, Tin, and Lead, and this was supposed to account for all the difference in the appearance and properties of the metals.

6 If the four metals, Copper, Iron, Tin, and Lead, were thoroughly cleansed or purified by art, it was expected that they would immediately change into Gold and Silver.

7 The substance, or material, for cleansing or purifying the four metals, Copper, Iron, Tin, and Lead, was to be named the Philosopher's Stone.

8 Copper, Iron, Tin, and Lead, are called common

metals, because they are plentiful and cheap. Gold and Silver are called precious metals, because they are scarce and valuable.

9 The process of changing the common metals into the precious metals was called Transmutation.

10 The word Transmutation is derived from the Latin words *trans*, across, and *muto*, to change.

11 The art of making the Philosopher's Stone, and of causing the Transmutation of metals, was called Alchemy, and the men who worked upon it were called Alchemists.

12 The word Alchemy is derived from the Arabic words *al*, meaning *the*, and *kema*, meaning *dark* or *secret*.

13 The word Alchemy, therefore, signifies the dark or secret art; and the word Alchemists, of course, signifies the workers, or the practisers of the dark or secret art.

14 The word Alchemy not only signifies that a secret was to be discovered, but that the operations for discovering the secret were to be kept in mystery.

15 The first Alchemists were Arabian sages, who lived during the time of Geber, in the seventh century.

16 The Alchemists collected all kinds of ores, minerals, earths, salts, animal and vegetable substances, thinking that some of these might be forced to yield, or united to make, the Philosopher's Stone.

17 The Alchemists constructed a great variety of earthen and glass vessels of curious shapes and different sizes, for holding the materials upon which hey worked; they also built furnaces and ovens for

heating them either fiercely or gently, for great hope was entertained that fire would force out, or make, the Philosopher's Stone.

18 The Alchemists also extracted and composed very powerful liquids, which would not only dissolve ores, minerals, earths, salts, animal and vegetable substances, but even all the six metals.

19 These contrivances and arrangements were denoted by the title of Apparatus, which is derived from the Latin, *apparo,* to prepare.

20 The building or apartment in which the apparatus was placed and operations conducted was called the Laboratory, a term derived from the Latin word *labor,* denoting to work.

21 The operations upon the various materials were called Experiments, a term derived from the Latin word *experior,* signifying *to try.*

22 These three terms, namely, Apparatus, Laboratory, and Experiments, very probably were not used at the commencement of Alchemy, but were introduced at a later date.

23 For many years the art of Alchemy was only known and practised in Arabia, but at length its principles were brought into Europe by the first Crusaders, upon their return from the Holy Land.

24 Spain was the first European country in which Alchemy was practised, but it quickly spread throughout the whole continent, and was incessantly followed up with great toil and labour, from the time of its introduction to the end of the sixteenth century.

25 Hundreds of books were written, pretending to teach the secrets of Alchemy, but the language was such a collection of hard words, riddles, and

puzzles, that nobody could understand its meaning, excepting the writers.

26 These books on Alchemy contain ingenious arguments that Transmutation could be performed, and formal testimonials from persons who said that they had actually performed it, or had seen it performed.

27 Such persons either deceived themselves, or were deceived by others, or else they signed their names to wilful falsehoods, for the sake of being thought extremely clever.

28 Although thousands and tens of thousands of experiments of every kind were made by fire and liquids upon the common metals, they could not be cleansed, or changed into the precious metals.

29 It is certain that Transmutation was never performed, although Alchemy was practised for upwards of eight hundred years.

30 True Alchemists, who firmly believed that Transmutation might be performed, spent their lives and fortunes in experiments, and generally died in disease and poverty.

31 False Alchemists, who believed no such thing, gained a comfortable living by making sham experiments for rich people who coveted to become richer, and offering to sell them the secret of making the Philosopher's Stone, and to instruct them in performing Transmutation for a certain sum of gold.

32 It appears wonderfully strange, but it is perfectly true, that such offers met with eager purchasers amongst the rich and avaricious.

33 If one man had the secret of making as much Gold as he liked, he had no cause to sell the secret to another man for a purse of money.

34 Therefore, when the false designing Alchemist asked the rich and avaricious man for money, it should have been a direct proof to him that there was no secret to be sold; but as he did not see this, his conduct proved the truth of the proverb that "Avarice makes men blind."

35 In the reign of Henry the Fourth all ranks of society became Alchemists; and so many splendid fortunes were lost, and so many persons were ruined by their folly in experiments upon Transmutation, that the practice of Alchemy was forbidden by an act of Parliament.

36 But things were so wonderfully changed in the reign of Henry the Sixth, that four letters patent were issued for encouraging the art of Alchemy, and dispensing with all former statutes and prohibitions to the contrary.

37 Although numbers of true and false Alchemists crowded forward to obey these commands, the coffers of the monarch were never enriched with a single grain of gold or silver made by the process of Transmutation.

38 The true Alchemists had a curious notion regarding gold, for as they found it to be an extremely durable metal, they thought that it might be made into a medicine which, if taken in a proper quantity, would confer durability upon the human body, or prolong life to any extent.

39 This golden medicine was called the Elixir of Life, but it did not engage so much attention as Transmutation, and it was quite abandoned upon the death of an Alchemist who impiously boasted that he held a vial of it in his hand.

40 The Alchemists discovered that gold might be dissolved, or rendered as liquid as water, and then they tried to make a substance that would dissolve everything; this substance they called the Universal Solvent.

41 They could not make the Universal Solvent, for, as it was to dissolve all things, it would of course dissolve their apparatus.

42 The three objects of Alchemy—namely, Transmutation, the Elixir of Life, and the Universal Solvent, were never accomplished, and at length the sad experience of repeated failure in all experiments convinced the Alchemists that their labour was utterly useless; therefore Alchemy was generally abandoned at the commencement of the seventeenth century.

43 During the vast number of years in which Alchemy was practised, the Alchemists discovered many wonderful things, but as these had no direct connexion with the three objects, they were passed aside, as of little or no value.

44 The Philosophers of the seventeenth century began an examination of the neglected relics of Alchemy, and soon discovered that many of them might be rendered serviceable as medicines, and others for the improvement of the arts and manufactures.

45 They wrote accounts of their investigations in plain language, arranged them into regular form and order, and earnestly endeavoured to point out that mankind would derive much benefit from the application of these new facts and materials to various useful purposes.

II. ORIGIN OF CHEMISTRY.

46 THESE writings, arrangements and classifications of facts and materials laid the foundation of a science called Chemistry.

47 The following curious-looking characters, namely, χ, η, μ, ε, ι, α, are Greek letters, and when they are placed together without the commas, as thus :—χημεια, they form a word, which English letters represent as thus :—*Chemeia.*

48 In the writings of some Greek authors, of the eleventh century, the word χημεια (*chemeia*) is used to denote the art of making gold, so that its meaning was precisely the same as the Arabic word Alchemy.

49 The true derivation, or, as a grammarian would say, the true root, of the word *chemeia* has not been clearly and satisfactorily discovered.

50 Some learned men think that *chemeia* is derived from *chemia,* one of the ancient names of Egypt, in which country the art of making gold was originally attempted.

51 Others think that the root of the word *chemeia* is the Coptic word *chems,* which means obscure, dark, or secret.

52 Others, again, imagine that the root of the word *chemeia* is the Greek word *chymos,* which means a juice, or a liquid.

53 If the word *chemia* be taken as the root of the word *chemeia,* it simply means that the art was of Egyptian origin.

54 If the word *chems* be taken as the root of the

word *chemeia*, it then denotes an obscure, dark, or secret art.

55 It is now well known that all experimental attempts to make gold by transmutation were conducted in obscurity and secrecy, and the word *chemeia* may not only refer to *this*, but also to the enigma of changing a lump of lead into a lump of gold.

56 If the word *chymos* be taken as the root of the word *chemeia*, it then denotes that a juice or liquid was employed in the attempts to make gold, and it is well known that more than one powerful juice or liquid was employed to assist in the work.

57 Some other words have been proposed as roots of the word *chemeia*, but those I have now mentioned are most probably correct.

58 If we adopt either *chemia* or *chems* as the root of *chemeia*, and wish to express it as an English word, we write it thus :—Chemistry.

59 If we adopt *chymos* as the root of *chemeia*, and wish to express it as an English word, we write it thus :—Chymistry.

60 It is of very little consequence how you spell the word, but of very great importance for you to remember that it no longer denotes the ancient and delusive art of making gold, for it is the distinctive title of a modern science of experiments upon the properties and components of all natural and artificial productions.

61 Such being the case, the Science cannot be defined in a few words, but a general notion of its objects, tendency, and applications, may be gained

from an attentive study of the ensuing pages of these Outlines of Chemistry.

62 In the first place, then, Chemistry is a science which teaches us that there are many substances called Principles, Rudiments, or Elements.

63 In the language of Chemistry, these three words all signify the same thing, or are *synonymous*, therefore, it hardly matters which of them we employ, but I think that we shall find the word *Elements* the most convenient for our purpose.

64 Well, then, Chemistry teaches us that these Elements are not Fire, Air, Earth, and Water, which are often called the four elements in some school books, and also in familiar conversation, but are totally different things, both in properties and number, as I shall fully explain to you in due time.

65 Chemistry teaches us that these Elements can unite or combine with each other in various ways, and that by so uniting or combining with each other, they make or produce Compounds.

66 Chemistry teaches us that Compounds containing two, three, or more Elements, can in their turn unite or combine with each other, and by thus uniting or combining with each other, they make or produce other Compounds.

67 When two, three, or more Elements unite or combine with each other, they make or produce what is called a Primary Compound.

68 When two, three, or more Primary Compounds unite or combine with each other, they make or produce what is called a Secondary Compound.

69 The terms Primary, Secondary, and Compound are derived from the Latin words, *primus*, meaning

first; *secundus*; meaning *second*, and *compons*, to place together.

70 Chemistry teaches us various methods of separating all known Compounds into their Elements, and of presenting these in their original states.

71 Chemistry teaches us the laws which govern these primary and secondary combinations, and their separation into their elements, and the *exact weights* in which all combinations and separations take place.

72 Lastly, Chemistry teaches us how all such knowledge may be employed in assisting the explanation of many wonderful changes that are always occurring throughout nature, and in contributing to the progress of the sciences and arts.

III. DEFINITION OF ELEMENTS AND COMPOUNDS.

73 THE term Element will frequently occur throughout these Outlines of Chemistry, and therefore I shall endeavour to explain the sense in which it is to be understood.

74 We are all well acquainted with the metal Lead: How is Lead made? of what is Lead made? of what things does Lead consist?

75 Although this may appear a very simple question, it cannot be answered, even by a Chemist; let him perform thousands of experiments upon the metal Lead, these will only alter or disguise its properties; and not discover to him the two or more things of which the metal may consist.

76 A Chemist is bound by the exact laws of his science to depend upon the *facts* that are disclosed by *Experiments*, and to draw conclusions *only* from them, and he must not indulge in speculation or guess-work concerning the substance under examination; if he did so, he would directly fall back into the condition of an Alchemist.

77 A Chemist, therefore, is obliged to confess his inability to tell of what things the metal Lead consists, and to be content with calling it an *Element.*

78 In the language of Chemistry, the term Element is used to denote a *substance which has not been experimentally proved to contain other substances*, or to be *made of other substances;* and such is the case with the metal *Lead.*

79 There is a substance called Litharge; it is well known to house-painters, who employ it for mixing with their oil colours; it is a heavy powder, of a light brown colour, and looking very much like dry powdered clay; the question is of what two or more things does this Litharge consist?

80 The Chemist endeavours to answer this question by making a number of experiments upon Litharge, and he soon ascertains that he can prove it to consist of *two* substances, he therefore does not call it an *Element,* but he calls it a *Compound.*

81 One of the substances of which Litharge consists is the heavy metal Lead; the other is a light invisible aeriform substance called Oxygen, for a reason that I shall very soon mention.

82 It is a most extraordinary fact, that heavy, solid, brilliant Lead, and light, invisible, aeriform Oxygen should constitute the clay-coloured powder called

Litharge; but the Chemist does not rest content with this discovery, he immediately endeavours to ascertain of what substances the Oxygen consists.

83 The Chemist discovers that aeriform and invisible Oxygen can be weighed and measured, with nearly the same facility as the solid metal Lead; but it cannot be parted or divided into two or more substances by any experiments, and as in this particular it agrees with Lead, he is obliged to call Oxygen an Element.

84 The operation of discovering the Elements of Litharge, or of any other Compound, is called Analysis, a term derived from the Greek words *ana*, signifying *thoroughly*, or *back to its sources*, and *luo*, signifying to *loosen*, or *unbind*.

85 The term Analysis is very expressive, for in Litharge the Elements Lead and Oxygen were united, or bound together, and are now loosened, or unbound, each coming forth in its original or pure state, and resisting all attempts at further analysis.

86 In other words, Lead and Oxygen are the *sources* from whence Litharge is *made* or *produced*.

87 It is of the utmost importance for you to remember that the operation of *Analysis liberates or educes Elements that actually exist in a Compound, and that it does not make or produce them by the introduction of the agents which are employed during the experiments*.

88 The Chemist discovers that the Elements which are thus educed by analysis will again unite, so that the Compound may be produced.

89 The operation of uniting Elements and so producing Compounds, is called Synthesis, a term derived from the Greek words *syn*, signifying *together*, and

tithemi, signifying *to place;* it is therefore the exact reverse of Analysis.

90 The term Litharge is derived from the Greek words *lithos*, signifying *stone*, and *arguros*, signifying *silver*, for anciently it was thought to contain silver; it does not contain that precious metal, but consists of the Elements Oxygen and Lead; it is therefore called in chemical language, Oxide of Lead, a term that has the advantage of directly expressing its composition.

91 Having proceeded thus far, the next question that presents itself to the Chemist is, how much Oxygen and how much Lead combine to produce Oxide of Lead?

92 In all strict experiments a Chemist employs most delicate scales and accurate weights; some of these weights are so small that you can hardly see them, as they are only equal to the one hundredth part of a single grain.

93 Provided, therefore, with such a beautiful apparatus, if the Chemist weigh 112 parts of Oxide of Lead, and then proceed to analyse such weight of the compound, he educes from it 8 parts by weight of Oxygen, and 104 parts by weight of Lead.

94 If the Chemist repeat the analysis of a similar weight of oxide of lead again and again, he will invariably obtain the same result.

95 When the Chemist thus works by weight, in order to ascertain quantities, he is said to perform Quantitative experiments, or, more commonly, Quantitative analysis.

96 When the Chemist works only with the view of

ascertaining the properties or qualities of a substance, without reference to the weight of its elements, he is said to perform Qualitative experiments, or, more commonly, Qualitative analysis.

97 There is a substance well known by the name of White Lead. It is a dry, heavy, white powder, which is often ground into a thick white paste with linseed oil, for the use of house-painters and decorative artists; the question presents itself to a Chemist; of what things does dry white lead consist? is it an Element, like the metal Lead, or is it a Compound, like Litharge?

98 The Chemist soon discovers that he can analyse White lead, and can educe from it Litharge, or Oxide of Lead, and an invisible vapour called Carbonic Acid, for a reason that I shall soon mention, and he accordingly concludes that White Lead is not an Element, but a Compound.

99 Having obtained this result, the Chemist next proceeds to place the Oxide of Lead and the Carbonic Acid together, and finds that these two substances will immediately unite, and make or produce White Lead.

100 The Chemist discovers that 134 parts by weight of White Lead by analysis yield 22 parts by weight of Carbonic Acid, and 112 parts by weight of Oxide of Lead, and that by synthesis these weights unite to produce again 134 parts of White Lead.

101 Thus, by analysis and by synthesis, finding White Lead to consist of Carbonic Acid and Oxide of Lead, he denotes the constitution or the formation of the Compound by the term Carbonate of Oxide of Lead.

102 But at this stage of inquiry arises another question—is Carbonic Acid an Element, or is it a Compound?

103 The operation of analysis discloses the curious fact that Carbonic Acid is not an Element, but is a Compound of the element Oxygen, and another element called Carbon.

104 The term Oxygen is derived from the Greek words *oxus,* meaning *acid,* and *gennao,* I *generate.*

105 The term Carbon is derived from the Latin word *carbo,* signifying *charcoal.*

106 When Oxygen combines with Carbon, an acid, or sour compound, is generated or formed, which acid, or sour compound, in consequence of consisting of Oxygen and Carbon, is called Carbonic Acid, to denote its composition.

107 Remember particularly that the element Oxygen does not invariably generate or form *acids,* when it combines with other elements, because it frequently produces compounds which are *not acid;* as, for example, when it combines with Lead, to produce *Oxide of lead,* which has no acid property; other examples of this fact will soon be presented.

108 Oxygen was discovered when the science of Chemistry was in its infancy, and as it was found to produce many acids, it was hastily supposed to be the *only* or the universal producer of acids, or the absolute acidifying principle, and therefore, in accordance with such supposition, it gained the name by which it is now commonly known.

109 I said (81) that Oxygen was an invisible aeriform substance, but, in the true language of Chemistry, I now tell you that it is called a Gas.

110 The term *Gas* is derived from the German word *geist,* signifying *spirit,* and is not exclusively used to denote oxygen, but every other aeriform substance which differs in its *actual* nature from the *air* that we breathe; provided that such substance never changes by intense cold into the form of a *liquid* or a *solid.*

111 I said (98) that Carbonic acid was an invisible Vapour; and this term, derived from the Latin word *vapor,* is used in the language of Chemistry to denote all aeriform substances that differ in actual nature from the *air* that we breathe, and that do change by intense cold either into the form of *liquids* or *solids.*

112 Thus, for example, steam is a *vapour;* if it be cooled it becomes *liquid* water, and if this be farther cooled it becomes *solid* ice.

113 The distinction between Gas and Vapour may be thus stated: a Gas is a thin aeriform substance, either elementary or compound, which resists condensation; a Vapour is a thin aeriform substance, either elementary or compound, which cannot resist condensation.

114 The term Condensation is derived from the Latin word *condenso,* signifying to *thicken.*

115 A gas cannot be condensed or thickened, to assume either a liquid or solid state, but a vapour can be condensed or *thickened* to assume either state.

116 The Chemist discovers that Carbonic Acid consists of 16 parts by weight of Oxygen, and 6 parts by weight of Carbon; and that in such

weights by synthesis these elements combine to produce 22 parts by weight of Carbonic Acid.

117 But the Chemist cannot discover of what two or more things Carbon consists, for it resists all attempts at analysis; and therefore, as in the case of Lead and Oxygen, he is compelled to call Carbon an Element.

118 Although Carbonic Acid and Oxide of Lead are both compound substances, in chemical language they are often called Proximate elements; the term proximate being derived from the Latin word *proximus*, meaning *nearest*, or *next*, because, during the analysis of White lead, they are nearest to the hands of the experimenter, or are the *first* things that are educed; and if he then place them together, they will at the *first* contact combine, and re-produce White lead, or Carbonate of oxide of lead.

119 Carbonic acid and Oxide of lead, although called Proximate elements, as I have just stated, admit of analysis, which educes from them Oxygen, Carbon, and Lead; but these three substances do not admit of farther analysis, and are therefore called Ultimate elements; the term ultimate is derived from the Latin word, *ultimus*, signifying *last*, or *uttermost*, because they are the *last* educts of analysis.

120 The Proximate elements of White lead, then, are Carbonic acid and Oxide of lead, but its Ultimate elements are Carbon, Oxygen, and Lead.

121 By analytical experiments, conducted with the greatest possible skill and accuracy, the Chemist discovers the important fact, that Elements unite

and produce Compounds, and that compounds, in their turn, unite, and produce other Compounds.

122 Oxide of lead is a primary compound, Carbonic acid is a primary compound; these combine, and produce Carbonate of Oxide of lead, which is a secondary compound.

123 When elements or compounds combine, they are said to have affinity for each other; the term affinity is derived from the Latin words *ad*, signifying *to*, and *finis*, a *boundary*.

124 The term affinity is not used in its literal sense, but in a figurative sense, to convey the idea that substances, although having different, or, it may be, opposite, properties, can manifest certain attachments or preferences for each other, and are thus induced to combine and produce new substances.

125 By the various operations of analysis, no less than *fifty-six* substances can be educed, which do not admit of farther analysis, or, in other words, of whose composition the Chemist knows nothing; and he is accordingly obliged to distinguish them by the title of Ultimate Elements.

126 Most of these are *solids*, others are either *liquids*, *gases*, or *vapours;* they can all be weighed, and are therefore often called Ponderable elements: the term ponderable being derived from the Latin word *pondus*, signifying *weight*.

127 There are three extremely subtle principles, or Elements, called Light, Heat, and Electricity, which cannot be weighed: these are called Imponderable elements, yet they exert wonderful power and influence over the states and combinations of the ponderable elements.

128 Chemistry teaches us to draw the conclusion, that by the mutual *combination*, and in some *few* cases, by the mutual *admixture* of the ponderable elements, in *certain or definite weights*, we are presented with *all* natural and artificial substances, so that its study is of vast extent, and its objects are inexhaustible.

129 Chemistry, unlike Alchemy, has no selfish or avaricious tendency; on the contrary, it has most intimate connexion with the welfare of all mankind, teaching, as it does, the applications of the products of the Creation to thousands of useful purposes.

130 Chemistry is exact in all its processes, certain in all its results, severe in all its reasonings, extensive in all its views, firmly established upon experiment, so that, in fact, there is no human occupation which it does not enlighten and improve.

131 Bearing in mind the conditions under which the term Element is employed in Chemistry—namely, to denote a substance which has not been analysed, we may proceed to enumerate the Fifty-six Elements, and examine the origin of the names by which they are distinguished.

132 I shall first present you with an alphabetical list of the Elements; the *left* hand of the list contains the names, and the *right* hand the usual manner of pronouncing them.

IV. ALPHABETICAL LIST OF ELEMENTS, AND PRONUNCIATION OF THEIR NAMES.

1.	Aluminum,	pronounced	Alu′minum.
2.	Antimony		Anti′mony.
3.	Arsenicum		Ar′senicum.
4.	Barium		Ba′rium.
5.	Bismuth		Bis′muth.
6.	Boron		Bo′ron.
7.	Bromine		Bro′mine.
8.	Cadmium		Cad′mium.
9.	Calcium		Cal′sium.
10.	Carbon		Car′bon.
11.	Cerium		See′rium.
12.	Chlorine		Clo′rine.
13.	Chromium		Cro′mium.
14.	Cobalt		Co′balt.
15.	Columbium		Colum′bium.
16.	Copper		Copp′er.
17.	Didymium		Didi′mium.
18.	Fluorine		Flewo′rine.
19.	Glucinum		Glu′cinum.
20.	Gold		Gold.
21.	Hydrogen		Hidro′jen.
22.	Iodine		Io′dine.
23.	Iridium		Irid′ium.
24.	Iron		I′ron.
25.	Lantanum		Lanta′num.
26.	Lead		Led.
27.	Lithium		Lithi′um.

28.	Magnesium	pronounced	Magnee'sium.
29.	Manganesium		Manganee'sium.
30.	Mercury		Mercu'ry.
31.	Molybdenum		Molib'denum.
32.	Nickel		Nickle.
33.	Nitrogen		Nite'ro'jen.
34.	Osmium		Os'mium.
35.	Oxygen		Oxi'jen.
36.	Palladium		Palla'dium.
37.	Phosphorus		Fos'fore'us.
38.	Platinum		Platti'num.
39.	Potassium		Potas'ium.
40.	Rhodium		Rode'ium.
41.	Selenium		Seelee'nium.
42.	Silicium		Sylee'syum.
43.	Silver		Sil'ver.
44.	Sodium		Sode'ium.
45.	Strontium		Stronti'um.
46.	Sulphur		Sul'fur.
47.	Tellurium		Tellu'rium.
48.	Thorinum		Thori'num.
49.	Tin		Tin.
50.	Titanium		Tita'nium.
51.	Tungstenum		Tungs'tenum.
52.	Vanadium		Vana'dium.
53.	Uranium		Ura'nium.
54.	Yttrium		Itt'rium.
55.	Zinc		Zink.
56.	Zirconium		Zir'conium.

134 I shall now proceed to enumerate the Elements individually, to explain in what forms they occur, and to give you the derivation of the names

by which they are denoted; for I dare say many of them appear to you as very mysterious and difficult.

V. NATURE OF THE ELEMENTS, AND DERIVATIONS OF THEIR NAMES.

135 I. ALUMINUM, *a metal*, educed from *clay*, the Latin name of which being *alumen*, becomes the root of the word Aluminum, which denotes *the metal of clay;* for clay is not an earth as it is commonly supposed to be, but is a natural or native compound of oxygen gas and the metal aluminum, or, chemically speaking, clay is a metallic oxide.

136 II. ANTIMONY, *a metal*, sometimes found naturally pure or native; but is more frequently educed artificially from its native combinations called ores. The term Antimony is derived from the Greek words *anti*, signifying *against* or *hostile to*, and *monos*, *one* or *solitary*, and was conferred upon the metal on account of several *monks* having been poisoned with its preparations, before its strength as a medicine was accurately determined.

137 III. ARSENICUM, *a metal*, artificially educed from its natural combinations by analytical processes; the term Arsenicum is derived from the Greek word *arsenicon*, signifying *powerful*, and was given to the metal on account of the extremely poisonous properties of all its compounds.

138 IV. BARIUM, *a metal*, educed from a heavy mineral called *baryta*, from the Greek word *baros*, signifying *weight*, hence the derivation of the term Barium to denote the metal, which, when com-

bined with oxygen, constitutes baryta or oxide of barium.

139 V. BISMUTH, *a metal*, sometimes found native, but generally educed from its ores. The name Bismuth is probably derived from the German words *weiss*, signifying *white*, and *muth*, *mother*, as it was formerly supposed to give birth to the precious metal silver.

140 VI. BORON, *a non-metallic combustible solid*, educed from a natural substance called *borax*, the name of which is derived from the Arabic word *buruk*, signifying *brilliant*, hence the derivation of the term *Boron*.

141 VII. BROMINE, *a non-metallic incombustible liquid*, educed from sea-water, eminently poisonous, and having a disagreeable odour; the term *Bromine* alludes to this, and is derived from the Greek word *bromos*, signifying *a stench*.

142 VIII. CADMIUM, *a metal*, educed from a mineral anciently called *cadmia* by the Greeks.

143 IX. CALCIUM, *a metal*, educed from Lime, the Latin name of which is *calx;* this becomes the root of the term *Calcium*, to denote the metal of lime; for although lime is familiarly called an earth, it is chemically a compound of oxygen and calcium, or a metallic oxide.

144 X. CARBON, *a non-metallic solid combustible*, which constitutes the greater part of the well-known substance charcoal; the root of the word *carbon* is the Latin word *carbo*, signifying *coal* or *charcoal*.

145 XI. CERIUM, *a metal*, educed from a scarce mineral, and is thus named in honour of the planet which is distinguished by the title of *Ceres*.

146 XII. CHLORINE, *a non-metallic incombustible vapour*, educed from common salt, extremely poisonous, and of a *greenish* yellow colour, to denote which the element is called Chlorine, a term derived from the Greek word *chloros*, signifying *green*.

147 XIII. CHROMIUM, *a metal*, educed from an ore, and thus named from the Greek word *chroma*, signifying *colour*, on account of the many colours assumed by its compounds.

148 XIV. COBALT, *a metal*, educed from its natural compounds or ores, and thus named from *Kobold* or *Cobalus*, a sprite that was superstitiously imagined to haunt certain mines, and cause as much perplexity to the operations of miners, as the metal caused to chemists before its nature was fully ascertained.

149 XV. COLUMBIUM, *a metal*, educed from an ore discovered in America, and thus named from the word *Columbia*, by which that continent is sometimes designated.

150 XVI. COPPER, *a metal*, often found native, but was anciently educed from its ores in the island of *Cyprus*, from which circumstance the name of Copper is derived.

151 XVII. DIDYMIUM, *a metal*, educed from some of its combinations; its name is derived from the Greek word *didumos*, signifying *twins*, on account of its *twin-like* resemblance to another metal.

152 XVIII. FLUORINE, *a non-metallic incombustible vapour*, which is supposed to exist in *fluor spar*, a substance thus named from the Latin word *fluo*, signifying to *flow* or to *melt*, on account of its melting readily, when heated with other minerals.

153 XIX. GLUCINUM, *a metal,* educed from a mineral called Glucina, from the Greek word *glukos,* signifying *sweet,* on account of the sweet taste of some of its compounds.

154 XX. GOLD, *a metal,* found in a native state. The derivation of its name is uncertain; perhaps it is from a Hebrew word, signifying to be *clear,* or *to shine.*

155 XXI. HYDROGEN, *a non-metallic inflammable gas,* educed from its natural combinations; and, strange to say, when it is *burnt,* it produces *water;* on this account it is called Hydrogen, the term being derived from the Greek words *hudor,* signifying *water,* and *gennao, I generate.*

156 XXII. IODINE, *a non-metallic incombustible solid,* educed from its natural compounds in seaweeds; when it is gently heated, it becomes a *vapour,* having a splendid *violet colour:* and on account of this distinctive property, the element is named Iodine, from the Greek word *iodes,* signifying *violet coloured.*

157 XXIII. IRIDIUM, *a metal,* educed from its native combination with another; and on account of its compounds generally having the colours of the *rainbow,* the metal is called Iridium, in honour of the *rainbow,* which is often styled the *iris.*

158 XXIV. IRON, *a metal,* sparingly found native, but abundantly educed from its ores; the derivation of the name Iron is extremely uncertain; it may be from a Hebrew word, signifying *to melt.*

159 XXV. LANTANUM, *a metal,* educed with great difficulty from its combinations, in which it remains *lurking* until powerfully experimented upon; to denote this property it is called *lantanum,* a term

derived from the Greek word *lanthano,* signifying to *conceal ;* it is the *twin* metal to Didymium.

160 XXVI. Lead, *a metal,* educed abundantly from its ores; its name is probably derived from the Greek word *molybdos,* by which the metal was anciently denoted.

161 XXVII. Lithium, *a metal,* educed from a *stony* mineral named Lithia, thus called from the Greek *lithos,* signifying *a stone,* hence the name *lithium,* which combined with oxygen produces lithia, or oxide of lithium.

162 XXVIII. Magnesium, *a metal,* educed from the white earthy-looking substance well known as Magnesia, on account of its having been discovered at *Magnesia* in Asia Minor; but magnesia is not an earth, it is a compound of oxygen gas, and the metal magnesium, and therefore a metallic oxide.

163 XXIX. Manganesium, *a metal,* educed from an ore called *manganese,* probably on account of its discovery at Mangana, in the East Indies.

164 XXX. Mercury, *a metal,* distinguished from all other metals on account of being invariably *liquid,* in temperate climates, but it may be rendered *solid* by intense cold ; it also becomes a *vapour* by a moderate heat; in allusion to its *liquidity,* and *quick* motions from one vessel to another, it was named *Mercury,* in honour of the planet which revolves the most rapidly around the sun, and on account of its *volatility,* or its flying about, was deemed to be the *messenger* of other metals, as the heathen deity Mercury was called the winged messenger of the gods.

165 XXXI. Molybdenum, *a metal,* educed from

its ores, and thus named from the Greek word *molybdos,* signifying *Lead,* for which metal it appears to have been originally mistaken.

166 XXXII. Nickel, *a metal,* educed from certain ores, and called by the German miners *kupfernickel,* signifying *false-copper.*

167 XXXIII. Nitrogen, *a non-metallic incombustible gas,* educed from the substance called *Nitre;* the term Nitrogen is derived from the Greek words *nitron,* signifying *nitre,* and *gennao, I generate,* because it *produces nitre.*

168 XXXIV. Osmium, *a metal,* educed from its native combination with Iridium; some of its other combinations have a pungent odour; the term Osmium denotes this, and is derived from the Greek word *osme,* signifying *odour.*

169 XXXV. Oxygen, *a non-metallic incombustible gas,* having a powerful and extensive affinity for the preceding, and the following metallic and non-metallic elements; in many cases when it combines with these *acids* are produced; hence it was originally termed Oxygen, from the Greek words *oxus,* signifying *acid,* and *gennao, I generate.*

170 XXXVI. Palladium, *a metal,* found native, and thus named in honour of the planet named after the goddess Pallas.

171 XXXVII. Phosphorus, *a non-metallic inflammable solid,* having the property of *shining* like a glow-worm or a fire-fly in the dark; the term alludes to this property, and is derived from the Greek words *phos,* signifying *light,* and *phero, to bear.*

172 XXXVIII. Platinum, *a metal,* found na-

tive; the name is either derived from the Spanish word *plata*, meaning *silver*, or from the word *platina* in the same language, meaning *little silver*, for platinum bears some resemblance to silver in whiteness.

173 XXXIX. Potassium, *a metal*, educed from *potash*; a substance so named on account of its having been originally obtained by burning common weeds to an *ash* in *iron pots;* accordingly, from the name potash is derived that of potassium, which, when combined with oxygen, produces potash, or, chemically speaking, oxide of potassium.

174 XL. Rhodium, *a metal*, found native, the compounds of which are generally of a *rose colour*, and on this account the metal bears the name of rhodium, it being derived from the Greek word *rhodon*, signifying *a rose.*

175 XLI. Selenium, a *non-metallic combustible solid*, educed from some of its native combinations or mixtures; it is thus named in honour of the moon, the Greek name of which luminary is *Selene.*

176 XLII. Silicium, *probably a metal*, but thought by some chemists to be *a non-metallic combustible solid;* it is educed from flint, the Latin name of which is *silex:* therefore the term Silicium means either the metallic or the non-metallic element of flint, which substance is not an earth, but a compound of oxygen and silicium.

177 XLIII. Silver, *a metal*, often found native, but more frequently educed from its ores: the derivation of the term Silver is extremely doubtful; perhaps it is from a Hebrew word signifying *money*, into which silver was coined in the earliest ages.

178 XLIV. Sodium, *a metal*, educed from *soda*, a

substance so named, on account of being obtained from the ashes of a plant called the *salsola soda;* accordingly from the name *soda* is derived that of Sodium, to denote the metal of soda, for soda is a compound of oxygen and sodium, or a metallic oxide.

179 XLV. Strontium, *a metal*, educed from a mineral discovered at *Strontian*, in Scotland, and named *strontian* in honour of its locality; from this is derived the term Strontium, which, combined with oxygen, produces the principle of the mineral which is an oxide of strontium.

180 XLVI. Sulphur, *a non-metallic inflammable solid*, plentifully found native and abundantly educed from its combinations with metals; the term Sulphur is probably derived from the Arabic language.

181 XLVII. Tellurium, *a metal*, educed from its combinations, and thus named in honour of the Earth, which in Latin is called *Tellus.*

182 XLVIII. Thorinum, *a metal*, educed from its combinations, and thus named in honour of Thor, a fabulous deity.

183 XLIX. Tin, *a metal*, educed from its ores; the derivation of its name is uncertain.

184 L. Titanium, *a metal*, educed from its combinations or mixture with other metals, and thus named in honour of the Titans of Heathen Mythology.

185 LI. Tungstenum, *a metal*, educed from a ponderous mineral called in the Swedish language *tungsten*, signifying *heavy stone.*

186 LII. Uranium, *a metal*, educed from a mineral, and thus named in honour of the planet *Uranus.*

187 Vanadium, *a metal*, educed from a mineral,

and is thus called in honour of Vanadis, a fabulous deity.

188 LIV. Yttrium, *a metal,* educed from a mineral found at Ytterby in Sweden, and thus named in honour of such locality.

189 LV. Zinc, *a metal,* abundantly educed from its ores; the term Zinc is supposed to be derived from the German word *zinken,* signifying *nails,* because the metal when melted and dropped into water, frequently sets into pointed particles resembling some kinds of *nails.*

190 LVI. Zirconium, *a metal,* educed from a precious mineral called *zircon* by the Ceylonese, which means *four-cornered,* in allusion to its shape: Zirconium, therefore, means the metal of Zircon, which is a metallic oxide.

VI. CLASSIFICATION OF ELEMENTS.

191 The greater number of the Elements are educed from their natural compounds by analytical processes; very few are presented naturally pure.

192 The names of the Elements which are presented naturally pure, or, as it is sometimes called, in *native state,* are, Antimony, Bismuth, Carbon, Copper, Gold, Iron, Mercury, Palladium, Platinum, Rhodium, Silver, and Sulphur.

193 The *fifty-six* Elements admit of arrangement or classification into *two* distinct groups, the *first* consisting of the *Non-metallic,* and the *second* of the *Metallic elements.*

194 Group I.—Three non-metallic Gases—namely, Hydrogen, Nitrogen, and Oxygen.

195 Two non-metallic Vapours—namely, Chlorine, and probably Fluorine.

196 ONE non-metallic Liquid—namely, Bromine.

197 SIX non-metallic Solids—namely Boron, Carbon, Iodine, Phosphorus, Selenium, and Sulphur.

198 GROUP II.—FORTY-FOUR Metals, all Solids with the exception of Mercury—namely, Aluminum, Antimony, Arsenicum, Barium, Bismuth, Cadmium, Calcium, Cerium, Chromium, Cobalt, Columbium, Copper, Didymium, Glucinum, Gold, Iridium, Iron, Lantanum, Lead, Lithium, Magnesium, Manganesium, Mercury, Molybdenum, Nickel, Osmium, Palladium, Platinum, Potassium, Rhodium, Silicium, Silver, Sodium, Strontium, Tellurium, Thorinum, Tin, Titanium, Tungstenum, Vanadium, Uranium, Yttrium, Zinc, and Zirconium.

199 Many of the Fifty-six elements are so extremely rare and unimportant, that their properties do not require the attention of a young student of the Science of Chemistry; the most important Elements are as follow:—

200 NON-METALLIC, Bromine, Carbon, Chlorine, Hydrogen, Iodine, Nitrogen, Oxygen, Phosphorus, and Sulphur.

201 METALLIC, Aluminum, Antimony, Calcium, Copper, Iron, Lead, Magnesium, Manganesium, Mercury, Platinum, Potassium, Silicium, Silver, Sodium, and Zinc.

202 Boron, Carbon, Hydrogen, Phosphorus, Selenium, and Sulphur are non-metallic Combustible elements.

203 Bromine, Chlorine, Fluorine, Iodine, and Oxygen are non-metallic Incombustible elements; but they aid the burning of the combustible elements.

204 Strictly speaking, the Metals are combustible elements, for the Chemist discovers they will burn when sufficiently heated by certain means which he can command; but the non-metallic element, Nitrogen, is *not* a combustible element, nor will it aid the burning of combustible elements.

205 You may consider the fifty-six Elements to bear the same relation to Compounds as the twenty-six letters of the Alphabet bear to the words of the English language.

206 Each word is a compound of two or more letters, into which it can be divided; but the letters themselves cannot be farther divided.

207 Some letters occur in words more frequently than others, for example—one or more of the vowels a, e, i, o, u, and y, are found in most parts of speech, whilst others, as the consonants, j, q, x, and z, enter into the constitution of very few words.

208 Thus, the Elements Oxygen, Hydrogen, Nitrogen, Carbon, Sulphur, and Iron, are found in a great number of compounds; whilst Selenium, Bromine, Uranium, and Zirconium, are only found in a very few compounds.

209 The fifty-six Elements may be called The Alphabet of Chemistry as a Science, and the different compounds correspond to the words which are made by the alphabetical letters.

210 Thus, Litharge is like a word of two letters, because it consists of the two Elements, Oxygen and Lead; White Lead is like a word of three letters, because it consists of the three Elements, Oxygen, Lead, and Carbon.

VII. EDUCTION OF ELEMENTS.

211 I HAVE stated that very few Elements are found naturally pure or in a simple state, and that most of them are educed from their compounds. I shall now endeavour to inform you how two or three of them are thus obtained, in order that you may form some notion of the principles upon which the Chemist works with the view of discovering the composition of substances.

212 The Chemist, after long experience, learns that certain ponderable and imponderable elements have most extraordinary *searching powers*, and therefore he selects these to constitute what may be called his detective force, or his class of inquisitorial agents for discovering the elementary, or the compound nature, of the substance which he submits to examination.

213 If a substance after undergoing every possible examination and cross-examination, by these agents or tests, remain unchanged in its original inherent condition, it must be regarded as a pure, simple, or Elementary substance.

214 If a substance during examination or cross-examination by these agents or tests, change or swerve from its original inherent condition, it must be regarded as containing other things, or as a Compound substance.

215 Whenever the Chemist finds it practicable, he always endeavours to employ the imponderable Elements, Heat and Electricity, as agents or tests in analysis; because, from their nature, they cannot introduce any ponderable matter into the substance upon which they are to operate.

216 But he cannot invariably employ Heat and Electricity as tests; and, therefore, when compelled to use ponderable Elements for the purpose, he, in the first place, submits them to a strict scrutiny, in order to ascertain their integrity, or freedom from adulteration, lest they should introduce foreign matters into the substance upon which they are to operate, and thus lead him to draw erroneous conclusions from his experiments.

217 A Chemist wishes to ascertain if Water, so familiarly called one of the Four Elements, really merits that distinctive title.

218 He knows that Heat is a powerful imponderable agent for producing singular changes in the state or condition of many substances. As, for example, it will change the metal Lead, from the state or condition of a solid into that of a liquid; or, in more familiar terms, Heat will melt solid lead.

219 You may say everybody knows that heat will melt lead, that there is nothing wonderful about the matter, and that surely it cannot be worth any consideration by a Chemist.

220 Remember, then, that a Chemist has to examine the reason of the appearances, and the changes which are presented by the most common, or, as you might think, the most trifling things; remember that he is seeking after knowledge; he is a Philosopher, a man of Science, and, by accurately observing and reasoning upon simple facts, he is frequently enabled to make discoveries of the utmost importance.

221 The term Philosopher is derived from he Greek words *philos*, signifying *lover of*, and

sophia, signifying *wisdom;* the term Science is derived from the Latin word *scientia,* signifying *knowledge.*

222 The melting of a solid piece of lead by Heat, although a familiar fact, is, nevertheless, a philosophical fact, or a scientific fact, and its examination will present some useful information.

223 A lump of Lead consists of an infinite number of minute particles of the metal, all of which are firmly drawn and held together by a certain attraction or force which prevents them from falling asunder, like the grains of a heap of sand.

224 This attraction, in scientific terms, is called the attraction of aggregation, or attraction of cohesion.

225 The term Attraction is derived from the Latin words *ad,* signifying *to,* and *traho, to draw.* Aggregation is derived from *ad,* signifying *to,* and *grego,* to *collect.* Cohesion is derived from *cum,* signifying together, and *hæreo, to stick.*

226 All substances are under the influence of this power of attraction of aggregation, or attraction of cohesion; it preserves them in what is called their tangible form or condition, either as solids, liquids, gases, or vapours.

227 The attraction of aggregation is strong amongst the particles of a solid, weak amongst those of a liquid, and weakest amongst those of a gas and a vapour.

228 Then, as regards the solid lump of Lead, when it is heated, the heat is said to weaken the attraction of aggregation, or of cohesion, amongst its particles, and to permit them to part asunder, or fall

into the liquid state; in which state attraction of aggregation, or of cohesion, is still exerted, although in a degree greatly inferior to that in which it was exerted in the solid metal.

229 When the melted Lead is removed from the fire, or, in other words, allowed to cool, the heat that unbound or loosened its solid particles gradually escapes, and the attraction of aggregation, or of cohesion, as gradually becomes stronger, until, at length, when the metal is cold, the attraction becomes as strong as it was at first, and the metal becomes as solid as it was at first.

230 By trials or experiments upon Lead and other metals, the Chemist soon discovers that Heat has the power, generally speaking, of changing the *condition* or the mechanical state of a metal from that of a solid to that of a liquid.

231 There are some instances, however, in which Heat has the power of changing the liquid metal into the state of vapour; and I may mention, that such is the case with the metal Zinc, and also with the metal Mercury, which is naturally liquid.

232 But in all these cases, even when the metal is converted into vapour, the Heat has only overcome the attraction of aggregation, the attraction of cohesion, or the mechanical attraction of its particles, to the utmost possible extent, and has not, in the slightest degree, overcome the force, the affinity, or the chemical attraction by which its constituents, whatever they may be, are naturally bound or united together.

233 Perhaps I can express these facts to you in other words, and you must not be tired if I repeat

things over and over again, for it is my wish to teach you with certainty, although it may be but slowly; and, therefore, if I find that you do not readily understand one form of expression, I try another, and another, until I find that you do clearly understand my meaning.

234 The Chemist discovers that Heat can only change the mechanical, and not the chemical, state of the metal. Take the extreme case, when it is converted into vapour; this, if cooled, will condense into the liquid state, and this, if further cooled, will concrete into the solid state, the metal coming forth in its original integrity, without having yielded the slightest cue as to its being a compound substance.

235 Heat, therefore, cannot effect the decomposition of a Metal. The term Decomposition is derived from the Latin words *de*, signifying *negative* or *not*, and *compo*, signifying *order*.

236 If Heat could effect the decomposition of a metal, by separating or tearing asunder the hidden things of which it may consist, these things would no longer be in the order in which they were when united in the form of a metal.

237 The term Decomposition has the same meaning as the term Analysis, or is synonymous with it; and, therefore, to say that Metals and other Elements cannot be decomposed, amounts to the same thing as to say that they cannot be analysed; but all compounds *can* be decomposed or analysed. I shall now proceed to examine Water, to prove whether it be an Element or a Compound.

238 If a solid lump of Ice be placed near a fire, it will gradually receive and absorb heat; this

will gradually weaken its attraction of aggregation or of cohesion, will gradually change the solid form of the water, and compel it to assume its more usual form of liquid.

239 If this liquid water be placed in a suitable vessel over a fire, the water will gradually receive and absorb more heat, and this will gradually weaken the attraction of cohesion amongst the liquid particles to a yet greater extent, and ultimately cause the liquid water to assume the state of vapour.

240 If this vapour be received in a cold vessel, it is immediately deprived of its extra portion of heat, and condensed into the state of liquid water, having a less portion of heat; if this liquid water be exposed to the cold of frost, it is even deprived of a portion of this heat, and congealed into the solid form of ice, having a least portion of heat.

241 But during the thawing of the solid ice into liquid water, during the boiling of the liquid water into steam or vapour, during the condensation of the steam into flowing water, during the congelation of flowing water into solid ice, however often the operations may be repeated, the attraction of aggregation or cohesion is affected throughout these changes, and *not* the attraction of composition or affinity.

242 In fact, throughout these changes, the Water, be it as a *solid*, a *liquid*, or a *vapour*, will yield *no clue* as to the things of which it may naturally consist; or, in other words, it comports itself like an Element, like the metal zinc, for example.

243 From these experiments, the Chemist is led to conclude that Heat, although a powerful imponderable agent, in modifying the form or state of

water, is ineffectual in discovering its composition; or, Water *may* be an element, or, if it be *not*, then its constituents or components must be united with an affinity so *strong* that they cannot be *parted* or torn asunder by heat.

244 The Chemist does not hastily conclude that Water *must be* an Element, or utterly incapable of decomposition, because it has resisted the ordeal of heat, but immediately seeks another imponderable agent, whose searching power may probably effect the desired analysis; and I must here again mention that no substance is deemed to be an Element until it is found to have resisted the power of every test that is known in the science of Chemistry.

245 There is a most wonderful imponderable agent, the peculiar properties of which were first discovered upon the examination of the substance so well known as Amber, and by degrees these peculiar properties were examined and arranged into regular form and order to constitute the rudiments of a science.

246 Amber was the means of revealing these peculiar properties of a new agent, and the Greek name of amber being *elektron*, the new agent received the name of Electricity, and the examination of its powers is distinguished as the Science of Electricity.

VIII. EDUCTION OF ELEMENTS,

Continued.

247 ELECTRICITY is discovered to be a natural agent, having the most extraordinary powers; some

of these I shall endeavour to explain fully at a more advanced period of your studies, but I may now tell you, that during a thunderstorm, the vivid flash of lightning announces the swift passage of electricity from the clouds to the earth, and that it not only forcibly parts asunder the intervening air, but violently rends into fragments terrestrial objects upon which it strikes, if they do not afford it a ready and unbroken track or passage.

248 The Chemist, by laborious and refined experiments upon natural Electricity, has succeeded in educing the agent by artificial means, and of subjecting it to control, so that it may be displayed in vivid sparks, or may be invisibly transmitted, with the swiftness of lightning, from one situation to another where its power is required to act.

249 With few exceptions, those elements and compounds which permit the passage of Heat also permit the passage of Electricity; and those which oppose or retard the passage of Heat will also oppose or retard the passage of Electricity.

250 The former are called Conductors, and the latter Non-conductors, or imperfect, bad conductors of Heat and Electricity. The term Conductors is derived from the Latin words *con*, signifying *together*, and *duco*, to *lead;* the word *non*, signifying *not*, prefixed to the word *conductors*, of course denotes *the reverse.*

251 Take a piece of iron wire, as thick and as long as the straight stem of a clay tobacco pipe, place one end of the iron wire and the bowl of the pipe side by side in a clear fire, you will soon find the other end of the iron wire become too hot for

you to touch, but the end of the stem of the clay pipe will feel as cold as it did before you thrust its bowl into the fire; by this simple trial or *experiment* you prove the iron and the clay to differ in their properties regarding heat when similarly treated.

252 Well, then, in the language of science, the Iron is said to conduct the heat from the fire, or to be a conductor of heat, and the Clay is said not to conduct the heat from the fire, or to be a non-conductor of heat, or, more correctly, an imperfect or bad conductor, for an absolute non-conductor, either of Heat or Electricity, is probably unknown.

253 Metals are the most perfect conductors of Heat, and also of Electricity; but stone, brick, and wood are imperfect conductors of these imponderable Elements; and I must here tell you that metals conduct Heat progressively, but conduct Electricity instantaneously.

254 I dare say that you have often observed a long iron rod, either attached to a building or affixed to a post near a building, and perhaps you may know that the iron rod is called a conductor, for the protection of the building from lightning.

255 As the iron wire that I have just mentioned is called a conductor of heat, so is the iron rod a conductor of electricity; the lightning will prefer being led through it from the clouds to the earth readily, rather than to dart amidst the imperfectly conducting stone, brick, and wood, and to find a tardy escape; thus, by the aid of a good conductor, the building is prevented from sustaining damage.

256 You know that water will soon boil when

placed over a fire, and, from what I have said, you may probably think that it must be a good conductor of heat to do so; such is not the case, for it is a most imperfect conductor of heat.

257 When water is placed, say in a copper kettle, over a fire, the metal soon conducts heat from the fire to the water that covers the interior bottom of the kettle. This water, by the contact of the hot metal, becomes extremely hot, but cannot part with, or impart any of the heat to the water above it or at the top of the kettle (as the heated end of the iron wire could to the cold end), because it is an imperfect conductor, and more resembles in this respect the clay stem of the tobacco pipe.

258 As the water in contact with the heated interior bottom of the kettle becomes hot, it at the same time becomes much lighter than the cold water at the top, therefore rises through it, and, in doing so, imparts heat by its touch or contact.

259 Portions of cold water then descend and come against the heated metal; these, in their turn, become hot, then rise and impart heat by contact; and so the process goes on, hot water ascending and cold water descending until the whole of the water boils.

260 Water, therefore, when heated at one part, does not conduct to another part, but it does convey heat; it does not become boiling hot on account of leading heat through, but on account of its conveying heat through; or, in other words, water has no power of conduction, but it has the power of convection.

261 The term Convection is derived from the

Latin words *con*, signifying *together*, and *veho*, to *carry;* and there is as much difference between *leading* and *carrying* as there is between *eduction* and *production*.

262 Perhaps you may think that all I have now mentioned appears to be a very roundabout way of obtaining an answer to the question as to the Elementary or Compound nature of Water; but I assure you that every word has connexion with the matter, and although it may appear rather a long task, it is short in comparison to that which a Chemist has to learn before he can prove all the foregoing steps by experiment.

263 Well, to continue. The Chemist arranges a suitable vessel or apparatus to contain a portion of water, so that it may be submitted to the agency of Electricity, and he discovers, in the first place, that water is an extremely imperfect conductor of the imponderable element; in the second place, that it has no convective power; and, in the third place, that it sustains no change; so that here again, as with Heat, Water comports itself as an Element.

264 Even in this case the Chemist does not hastily conclude that Water must absolutely be an Element because it does not yield to the first application of Electricity. He next tries if he can modify the application of the agent, that it may exert its analytic power.

265 He reflects upon a well-known fact of frequent occurrence during a thunder storm—namely, if the iron conductor of a building be not perfect or continuous, if there exist the slightest break in it,

the lightning, upon arriving at such defect, and therefore having its swift passage retarded, will dart from the conducting iron amidst the imperfect conducting stone, brick, or wood work, and cause fracture or disintegration.

266 The term Disintegration is derived from the Latin words *dis*, signifying *separation*, and *integer*, *the whole, the complete.* It denotes the *opposite* of aggregation, or, in other words, a *falling away* of particles.

267 The Chemist reflects, if natural electricity can thus cause the mechanical disintegration of imperfectly conducting substances, artificial electricity may be so modified and applied as to effect the chemical decomposition of some imperfectly conducting substances, and therefore he tries its effect upon water, in the manner that I shall next describe.

268 Let me call your attention to the following arrangement of letters :—

A. W. C.

269 Let W represent water, and A and C wires of the metal platinum dipping into the water, but not touching each other.

270 If A be placed in connexion with an artificial source of electricity it will receive the electricity, and endeavour to conduct it to C.

271 But A cannot, directly or instantaneously, conduct electricity to C, on account of W, the imperfect conducting water that is between them.

272 This water, W, interrupts and retards the passage of the subtile imponderable element, which

then exhibits its power of producing an extraordinary change in the water.

273 For around the platinum wires A and C, thousands and thousands of bubbles come forth, rise rapidly, and burst upon the surface of the water, so that it appears as if it were furiously boiling.

274 Here, then, is a wonderful change, effected by interrupting the passage of electricity from one good conducting surface of metal to another, by the intervention of imperfectly conducting water.

275 The Chemist soon ascertains that the water is not boiling; that he can bear to plunge his hand in it; that the bubbles are not bubbles of hot steam, but are bubbles of cold gas, and that they do *not condense* as they would if they were bubbles of steam.

276 He therefore infers from this experiment that water is unable to withstand the searching power of this modified application of electricity, and that the bubbles of gas are *elements* actually *educed* from the *water;* or, in other terms, *water admits* of *decomposition* by this *interrupted* passage of *electricity*, although it resisted decomposition by a more *direct* passage of that imponderable agent.

277 The Chemist devises methods of collecting the gas from A and the gas from C, and soon discovers that they *are not alike* in their properties.

278 The gas from A, where electricity *enters* the water, is invisible as air; and if a lighted taper be placed in it the brilliancy of the flame is remarkably increased; nay, if the flame be blown out so that the wick may be left with a red-hot snuff, upon placing this in the gas the

taper will be rekindled, and the flame will burn with increased brilliancy, but the gas itself *will not* kindle and burn.

279 The gas from C, where the electricity *escapes* after crossing from A through W, is invisible as air; and if a lighted taper be placed in it the flame is instantly extinguished, but the gas itself *will* kindle and burn with an extremely pale flame.

280 The result thus obtained, by submitting water to the action of Electricity, is of the highest possible interest to the Chemist; and he farther discovers that, by prolonging the action for a sufficient time, the whole of the liquid water vanishes into the two gases which have such distinct and opposite characters.

281 The Chemist then submits these gases to every imponderable and ponderable test, but finds that they resist all attempts at decomposition, and in fact they must be considered as Elements educed from Compound Water.

282 He experimentally proves them to be the elements of water; for if he place them together, and cause a spark of electricity to pass through the mixture, the subtile agent, thus applied, will excite the gases to exert affinity for each other; they will combine instantaneously; and the *identical water* is *produced,* from whence, by the interrupted passage of electricity, they were *educed.*

283 The gas educed at A, where the electricity *enters* the water W, is the Element called Oxygen.

284 The gas educed at C, where the electricity *escapes* from the water W, is the Element called Hydrogen.

285 The decomposition of Water by electricity is generally distinguished by the term Electrolysis (pronounced *elektrol'isis*); it is derived from the Greek word *elektron*, signifying *amber*, from whence is derived the term *electricity*, and *luo*, to *loosen*, Therefore *Electrolysis* denotes to loosen, or unbind, by electricity.

286 This Electrolysis of water is of a most certain or definite nature; the Chemist examines it in every particular with the most unwearied skill, and discovers many extraordinary facts in connexion with it, a few of which I may now mention.

287 First—That Oxygen is invariably educed where electricity *enters* at A, and Hydrogen is invariably educed where electricity *escapes* at C.

288 Secondly,—That the quantity by measure of the Hydrogen educed at C, is invariably double the quantity by measure of Oxygen educed at A.

289 Thirdly,—That the quantity by measure of Hydrogen educed at C, invariably equals *one* part by weight, and the quantity of Oxygen educed at A, as invariably equals *eight* parts by weight.

290 Fourthly,—That the *one* part of Hydrogen by weight, and *eight* parts of Oxygen by weight, combine and produce *nine* parts of Water by weight.

291 Thus then, by Electrolysis, the Chemist can educe from their natural combination in water, the Elements called Oxygen and Hydrogen, and can prove both analytically and synthetically that Water, although it has for ages borne, does not merit the title of Element, as it is a definite compound of the gases Oxygen and Hydrogen.

292 The accurate and extensive investigation of

the properties of these remarkable elements demands the attentive study of the Chemist; he performs many beautiful experiments upon them.

293 I have only selected their eduction now, to give you a slight notion of the train of reasoning and of experimental research that is required for endeavouring to effect analysis by the employment of Imponderable agents. I shall next present you with the principles of an analysis, or decomposition, and the eduction of an element by the employment of a Ponderable agent.

IX. EDUCTION OF ELEMENTS,
Concluded.

294 The Chemist wishes to ascertain if the ancient Element Air, still merit its distinctive title; he therefore tries upon it the effect of Heat and Electricity; he finds, although Heat can render Air lighter, and Electricity can dart through air, that neither of these agents can *educe* any substance or substances from Air; and he finds that the third imponderable Element Light, has no effect upon Air.

295 The Chemist, therefore, seeks for some ponderable agent for effecting the analysis or the decomposition of Air; he reflects upon the fact that the common metals, if bright, become dull or tarnished, especially when they are heated. Thus a bright iron nail will soon become dull or tarnished, if it be heated red-hot in the fire for a few minutes.

296 This fact may appear to you as trifling as that regarding the metal Lead melting by heat, but you have gained a large amount of information from the examination of that fact; so you will add

to such information by the examination of the cause of a hot iron nail tarnishing.

297 Is the tarnish of the hot iron produced in consequence of the metal exerting affinity for and combining with Air itself, or is it produced in consequence of the metal exerting affinity for and combining with an element or elements that the Air contains?

298 This question can only be answered by making accurate experiments.

299 The Chemist ascertains that the liquid metal Mercury will tarnish by heat in a more remarkable manner than the metal iron, and, being liquid, it admits of introduction into an apparatus more readily than a solid metal; he, therefore, selects Mercury as a ponderable agent for effecting, if possible, the desired analysis of Air.

300 He introduces a portion of brilliant liquid Mercury into a glass apparatus containing a certain measure of Air, and contrives a method of preventing either the metal or the air from escaping.

301 In the Air thus confined he heats the Mercury, and finds, after a time, that the original measure of the Air is much diminished. He still heats the Mercury, until he ultimately finds that the Air suffers no more diminution.

302 During this experiment, the Chemist remarks that the liquid Mercury, which was originally white and brilliant as silver, has become tarnished and covered with solid grains of a deep red colour.

303 Now, the Alchemists frequently made an experiment of this kind, not with the view of effecting the analysis of air, but with the view of

rendering the mercury solid, in which state they imagined it would present them with *pure silver.* Finding, however, that it did not become a solid of metallic lustre, but grains of a deep red colour, having no resemblance to a metal, they inferred that the Mercury was changed or transmuted into a red-coloured earth.

304 The Chemist reasons differently regarding the remarkable result of the experiment, and he concludes that the heat has excited the Mercury to exert an affinity, not for the entire measure of the confined air (because a very considerable measure yet remains), but for a part of the confined air, or it may be for a certain element of the confined air.

305 And farther, that the Mercury, having thus operated, has no affinity for the remaining portion of the confined air, or the remaining probable element of the confined air; which accordingly suffers no more diminution in its quantity or measure.

306 In other words, the Chemist expects that the Mercury has abstracted and combined with one element of the air to produce the red-coloured compound, and so has educed the other element of the air in its pure state.

307 He examines this remaining aeriform substance, and finds that it will instantly extinguish the flame of a taper, and that it will not itself kindle and burn; so that it cannot be Oxygen—it cannot be Hydrogen.

308 The Chemist ascertains that the aeriform substance is not a vapour, for it will not condense either into the liquid or solid form by the action of he most intense degree of cold. It is, therefore, a

perfect gas, which, after being submitted to all the most powerful tests or detective agents, will not yield any other substances; it resists decomposition, and therefore merits the title of an Element.

309 It is an Element identical in every character with an element that can be educed from *Nitre*, and without which element Nitre *cannot* be produced. It is, therefore, distinguished by the term Nitrogen, which is derived from the Greek words, signifying *nitre*, and *generate* or *produce*, as I have already mentioned.

310 The Chemist therefore deems Nitrogen to be one of the gaseous elements of Air. The other element he suspects to have combined with the Mercury to produce the red compound, he therefore proceeds to analyse this, and to educe the element from its curious combination.

311 As in the case of Water, electricity of one degree was found to effect its decomposition into the elements Oxygen and Hydrogen, and electricity of another degree was found to effect their combination to produce Water; so in the case now before you. The Chemist ascertains that heat of one degree will produce the red-coloured compound, whilst heat of another degree will cause it to decompose.

312 The metal Mercury, when exposed to heat, will boil before it becomes red-hot, and the heat required for its boiling is exactly sufficient for exciting affinity to ensue between it and the other element of the air, the result of which affinity is the production of the red compound.

313 If this red compound be heated red-hot, this greater degree of heat overcomes not only at-

traction of aggregation or of cohesion, but the attraction of composition or the affinity between the Mercury and the unknown element, they are parted or torn asunder, the Mercury is educed in its original brilliant liquid state, and the unknown element is educed and collected in an aeriform state. The whole of the red compound vanishes, or, in other words, it is entirely decomposed.

314 The Chemist next examines the aeriform substance, and discovers it to be identical in all its characters with the Oxygen which he educed from Water.

315 He mingles the Oxygen and the Nitrogen together, in precisely the same proportions by measure in which he found them educed, and finds that the *mixture* has the same effect upon the flame of a taper as the *air* originally had: I mean that it will support the flame with its usual steady brilliancy.

316 As the *mere mixture* of the elements is sufficient for this purpose—as there is no occasion previously to excite affinity between them (as there was in the case of Oxygen and Hydrogen to produce *compound water*)—the Chemist concludes that the *air* is *naturally* a *mere mixture*, and *not* a true compound of the elements Oxygen and Nitrogen.

317 The Chemist having ascertained these facts, proceeds to determine them yet more accurately by weight, and discovers that one thousand parts of Air by weight yield seven hundred and seventy parts by weight of Nitrogen, and two hundred and thirty parts by weight of Oxygen; or the result may be stated as follows:—

$$\left.\begin{array}{l}\text{Nitrogen . . . . } 770\\ \text{Oxygen . . . . } 230\end{array}\right\}=\text{Air, } 1000.$$

318 The red compound, so often mentioned in the foregoing description, is discovered to be, not an earth, but a compound of Oxygen and Mercury, and as it has no acid property, it is called an Oxide of Mercury, to denote its true composition.

319 When the bright iron nail is placed in the fire the heat excites affinity to take place between the oxygen of the air (which supports or fans the fire) and the metal iron, the tarnish is thus produced, and it being a compound of Oxygen and Iron, and having no acid property, is called an Oxide of Iron, to denote its true constitution.

320 The Oxygen and the Iron have most intense affinity for each other, and when once *combined* by the exciting agency of a certain degree of heat, they cannot be parted by the very highest degree of heat that is known to the Chemist.

321 The experiments I have now mentioned, and many others of similar nature that are well known to the Chemist, but rather too difficult for you to understand, prove beyond doubt that the *Air* does *not* merit its ancient title of *Element*, nor even that of *Compound*, as it is *only a mixture* of the *Elements Oxygen* and *Nitrogen.*

322 Having thus discovered that Water and Air admit of decomposition or separation into other substances, I may tell you that the ancient element, Earth, by which term was denoted every variety of rock, stone, and soil, has yielded to chemical analysis, and that clay, lime, and sand, for example, are

compounds of Oxygen with Metals, or are metallic oxides.

323 Fire is no longer regarded or acknowledged to be an element, as it was anciently thought to be, but is in every case a result of strong or powerful chemical affinity between two or more elements. Thus, a fine dust of Lead placed in Oxygen immediately takes fire and burns, the Fire here results from an intense affinity between the two elements, causing them to unite and produce the compound Oxide of Lead.

324 From what I have said, I think that you have formed some notion of the operations of analysis, by which are educed the three modern elements, Oxygen, Hydrogen, and Nitrogen; now, remember that they are the only Elementary Gases known, and that they enter into the composition of a vast number of natural and artificial substances, the accurate study of which would occupy the lifetime of the most talented and industrious experimenter.

325 Then as regards the other modern elements, of which I presented you with an alphabetical list, and more particularly as regards the Metals, those which are not found native are educed by analysis from their combinations, and such combinations, when they contain metals, are usually called metallic ores.

326 These, generally speaking, are natural combinations of Metals with oxygen, chlorine, sulphur, or other non-metallic elements, and are respectively called oxides, chlorides, and sulphurets, to denote their composition.

327 The art of educing metals from ores, consists in presenting to these some element or elements

having a greater affinity for the oxygen, the chlorine, or the sulphur, than the metals naturally have for those substances, so that by removing these non-metallic elements, the metals themselves are set free, or are educed.

X. WEIGHTS OF THE ELEMENTS.

328 I HAVE frequently mentioned to you during this course of instruction, that in all accurate or quantitative experiments the Chemist invariably works by *weight*, and now I wish to explain this matter more particularly, as it is of great interest and importance.

329 The Chemist has invented methods for collecting Hydrogen, although it is a perfectly invisible gas, and of filling bottles with it as easily as you can fill bottles with water; he can also weigh the gas more accurately than you could weigh a lump of lead, with his delicate scales and weights, and he ascertains that Hydrogen is the *lightest* substance with which he is acquainted.

330 On this account he distinguishes Hydrogen as equal to *One*, or *Unity*, and selects this as a *mark* or *standard* by which to compare the *relative weights* of other *Elements*, or the *definite weights* in which they *combine* with *Hydrogen* and *with each other*.

331 Now, remember, for the future, when I say 1, 2, 3, 4, 5, or any other number of parts, I always mean *parts by weight;* if you remember and understand this, it will save both of us much time and repetition of terms.

332 The Chemist ascertains that 1 part of Hy-

drogen will combine with 8 parts of Oxygen—that 8 parts of Oxygen will combine with 104 parts of Lead; and if these *numbers* represent the *combining weights of the elements*—as 1 of Hydrogen *combine* with 8 of Oxygen, as 8 of Oxygen *combine* with 104 of Lead—the *numbers* 9 and 112 will respectively *represent* the *compounds* that are *formed*—namely, Water 9, and Oxide of Lead 112.

333 The numbers 1, 8, and 104, denote the *smallest combining weights of the elements;* the numbers 9 and 112 denote the *smallest weights, and combining weights of the compounds.*

334 It frequently happens that Elements will combine in *more than their smallest weights,* and then it is found that such *greater weights* are always *simple multiples* of the *smallest* or *first combining weights.*

335 Thus, 8 of Oxygen combine with 6 of Carbon to form 16 of Carbonic oxide, but *twice* 8, or 16, of Oxygen combine with 6 of Carbon to form 22 of Carbonic acid.

336 Thus *three* times 8, or 24, of Oxygen combine with *twice* 104, or 208, of Lead to produce 332 of an Oxide of Lead, very different to the Oxide of Lead represented by the number 112.

337 This Oxide, however, represented by 112, combines with 22 of Carbonic acid, so that Carbonate of Oxide of Lead is represented by the number 134.

338 The combining weights of Elements and Compounds, you will thus perceive, are not represented at so much in each 100 parts, or at so much *per cent.,* but in their *smallest possible weights,* in

reference to the elementary *standard of hydrogen*, as being *equal to* 1, or *equal to unity.*

339 It is very probable that soon after commencing the study of these Outlines of Chemistry, you thought it rather strange that I should say 112 parts by weight of Oxide of Lead, 22 parts by weight of Carbonic Acid, and 134 parts by weight of Carbonate of Oxide of Lead, instead of saying 100 parts of each, and educing the *per centages* of the Oxygen, the Lead, and the Carbon. Now you find the reason that I so expressed myself, which I could not have rendered intelligible to you at that time.

340 I shall now present you with another Alphabetical List of The Ultimate Elements, and call upon you to remember most particularly the numbers on the *right hand* of the names which are printed in CAPITALS, as they denote Elements of the greatest importance, and I shall constantly have to mention them at a more advanced period of your studies.

341 ALPHABETICAL LIST OF ULTIMATE ELEMENTS. The numbers placed on the *right hand* denote the *smallest weight* in which they combine. HYDROGEN being taken as the *Standard of Comparison or Unity.*

NAMES OF ELEMENTS.	COMBINING WEIGHTS.
1 ALUMINUM	10
2 ANTIMONY	65
3 ARSENICUM	38
4 Barium	70
5 Bismuth	72
6 Boron	20
7 BROMINE	78

NAMES OF ELEMENTS.	COMBINING WEIGHTS.
8 Cadmium	56
9 CALCIUM	20
10 CARBON	6
11 Cerium	48
12 CHLORINE	36
13 Chromium	28
14 Cobalt	30
15 Columbium	185
16 COPPER	32
17 Didymium	?
18 Fluorine	18?
19 Glucinum	18
20 Gold	200
21 HYDROGEN	1
22 IODINE	125
23 Iridium	96
24 IRON	28
25 Lantanum	40
26 LEAD	104
27 Lithium	10
28 MAGNESIUM	12
29 MANGANESIUM	28
30 MERCURY	200
31 Molybdenum	48
32 Nickel	28
33 NITROGEN	14
34 Osmium	100
35 OXYGEN	8
36 Palladium	54
37 PHOSPHORUS	32
38 PLATINUM	96
39 POTASSIUM	40

NAMES OF ELEMENTS.	COMBINING WEIGHTS.
40 Rhodium	45
41 Selenium	40
42 SILICIUM	8
43 SILVER	110
44 SODIUM	24
45 Strontium	44
46 SULPHUR	16
47 Tellurium	32
48 Thorinum	60
49 Tin	58
50 Titanium	24
51 Tungstenum	109
52 Uranium	217
53 Vanadium	68
54 Yttrium	32
55 ZINC	32
56 Zirconium	30

342 A correct knowledge of these smallest or combining weights is of the greatest importance to the Chemist; it enables him to attain a degree of precision in experimenting which was unknown at the commencement of Chemistry.

343 I may tell you also that Primary and Secondary combinations cannot be formed in any weights that the caprice or inclination of the chemist may dictate; as, for example, 100 of A with 200 of B, at one time, and 100 of B with 200 of A at another; they can only be formed in certain or *definite weights* or in some *simple multiples* of such weights.

344 Hence the great beauty and precision of Chemistry, in addition to the curious and unexpected changes that its experiments present; and there-

fore its study becomes a pleasurable task to every active and diligent mind; for it is perfectly impossible to anticipate what results will be obtained when either elements or compounds are experimented upon, and caused to exert affinity for each other.

345 New discoveries are daily made, and are, generally speaking, applicable, either directly or indirectly, to the improvement and advancement of the useful arts.

346 The most learned grammarian is unable to state the exact number of words that can be formed by the twenty-six letters of the Alphabet: the most talented chemist is unable to state the exact number of primary and secondary compounds that can be formed by the fifty-six Ultimate Elements; but a sound general knowledge of the powers and properties of those which are of the most frequent occurrence, exactly the same as in the case of a language, is well calculated to enlarge and enlighten the understanding, and so enable us to appreciate the great value of the treasures which are so abundantly presented for our examination, through the vast temple of the sciences.

XI. UTILITY OF CHEMISTRY.

347 LOOK where you may throughout the vast, the varied, the magnificent Creation, earth, water, air, vegetables, and animals, are all presenting you with their respective volumes of wonders, the pages of which you are permitted to examine and to in-

terpret, to a great extent, by the aid of the Science of Chemistry.

348 For example, Chemistry directs your attention to the various rocks and stones upon the surface of the earth, proves to you the elements of which they are composed, how far they are affected by the weather, and, therefore, how far they are suitable for employment as materials for building.

349 Chemistry teaches you how to place the components of rocks, stones, or soils—such as clay, sand, and lime together, in weights different to those in which they naturally occur, so as to produce artificial materials, such as brick, mortar, plaster, cement, and stucco, for building either simple or decorated structures.

350 Aided by the science of Mechanics, Chemistry leads you far beneath the level of the earth, into the deep region of the mines, glittering with veins of native metals or metallic ores; teaches you how to extract or educe the useful metals from substances, or elements, of lesser value; and to melt and mould the metals into forms suited for the purposes of the arts, manufactures, and domestic life.

351 Chemistry points out the boundless stores of mineral fuel, called Coal; teaches you that it chiefly consists of the inflammable elements Carbon and Hydrogen; and how it may be burned to produce heat of sufficient power to melt solid iron and other metals, in which molten state, but more especially iron, they may be cast into moulds, and so become serviceable in the construction of those stupendous works of art, such as railways, bridges, steam en-

gines, and machinery, for which this country is so renowned.

352 Chemistry teaches you how to burn coal in common fire-places, so as to obtain the greatest heat with the least weight of fuel, by admitting to it a proper supply of Air, the Oxygen of which supports the combustion of the Carbon and the Hydrogen, producing the vapours of Carbonic Acid and Water, which are allowed free escape through the chimney, whilst fresh air enters the grate to maintain the combustion of other portions of the fuel.

353 If, instead of warmth, it be your object to obtain useful light, Chemistry teaches that, by heating coal in a vessel closed against the admission of air, or, in other words, an *air-tight* apparatus, that the coal is decomposed, and a great portion of its Carbon and Hydrogen arrange themselves, by affinity, into the form of an invisible vapour, commonly called Coal gas, but chemically, Carburetted Hydrogen; with which cities, towns, and highways may be brilliantly illuminated.

354 Chemistry instructs you how to melt certain weights of sand, or oxide of silicium and potash, or oxide of potassium, that the two compounds may combine, and produce a third compound which is familiarly known to you as Glass.

355 Chemistry likewise instructs you how this glass may be farther combined with oxide of lead, to produce another kind of glass, clear and colourless as the purest ice, or to combine glass with other metallic oxides to produce artificial gems, which rival in colour the crimson, yellow, blue, purple, and green of the native ruby, topaz, sapphire, amethyst, and emerald.

356 The oxides having the peculiar colouring property are those of gold, silver, cobalt, manganesium, and chromium.

357 Every kind of this invaluable compound of metallic oxides, whether it be colourless or coloured glass, is employed for useful or ornamental purposes, and little do you imagine when you are looking at a common window, or admiring one of stained glass, the amount of information chemistry can teach you to derive from either the one or the other; it would include an accurate history of many metallic and non-metallic elements.

358 Chemistry directs you how other sciences may be assisted by its discovery of colourless glass. The astronomer moulds and grinds it into lenses, having an enormous magnifying power, and so constructs a telescope to aid him in ascertaining and watching the forms, appearances, and motions of the starry heavens.

359 The naturalist employs glass lenses of enormous magnifying power in his microscope for examining the structure of those minute particles of animate and inanimate substances, which elude investigation by the unassisted eye.

360 Chemistry teaches you how to mingle flint, or oxide of silicium, and clay, or oxide of aluminum, together in certain weights with water, and thus form a soft plastic material that may be moulded or pressed into various shapes. It teaches how these may be dried to expel the greater part of the water, and then heated red-hot to expel the remainder, and excite the mixture of the oxides to exert affinity for each

other, and combine into a hard, brittle white compound, familiarly known as pottery or earthenware.

361 Chemistry teaches how this earthenware may be rendered capable of holding water or other liquids, by filling its pores with oxide of lead (or oxides of other metals), which, when heated red-hot, will enter into combination with the oxides of silicium and aluminum, superficially, and thus encrust the vessels with a transparent insoluble variety of glass, commonly known as glaze.

362 Chemistry teaches how the white mixture of oxide of silicium and oxide of aluminum may be combined with other metallic oxides which have the power of conferring colour, and thus you are presented with coloured earthenware, or designs are painted upon the white earthenware with metallic oxides, and various mixtures of them, which, when the vessel is heated red-hot, combine and produce the colours or tints that the artist desired.

363 The metallic oxides which are employed for colouring earthenware, and for painting on porcelain, are generally the same as those employed for colouring glass; and the whole perfection which has been attained in the production of glass, pottery, and porcelain, is owing to the introduction and skilful employment of chemical principles and chemical preparations.

364 Chemistry displays its utility even in a more striking manner, when you examine the arts of dyeing and calico printing, for in them either elements or primary or secondary compounds are employed for tinting woven fabrics, either entirely, as in dyeing cloth, or partially, as in printing calico. All those

beautiful dyed cloths and printed calicoes that you see in warehouses and shops, are produced upon chemical principles, after long and laborious study and experiments upon the affinity that substances have for each other.

365 Chemistry teaches you how to destroy colour, or to bleach coloured materials: indeed the modern art of bleaching is exclusively dependent upon chemical principles. The elementary vapour Chlorine educed from common salt, which is a natural compound of Chlorine and Sodium, and therefore called Chloride of Sodium, is the agent selected for use in the art of bleaching.

366 Chemistry proves the extraordinary fact that the element Chlorine will not bleach dry colours; but let them be wetted, and then Chlorine will decompose the Water, combining with its Hydrogen to produce an acid called Hydrochloric acid, to denote its composition, and educing Oxygen, which elementary gas, at the instant of its eduction, has the property of bleaching colours.

367 I may just call your attention to the fact of the production of Hydrochloric acid from the combination of Chlorine and Hydrogen, as it is one of the many acids which are not generated by Oxygen, and which do not contain Oxygen.

368 For the decomposition of Water by Chlorine, chemistry teaches how that element may be most advantageously educed and applied, and the art of bleaching conducted upon an enormous scale, which you may readily believe, if you merely glance into the warehouses and shops which contain thousands of bales of calico and other goods of snowy whiteness.

XII. UTILITY OF CHEMISTRY.

(*Conclusion.*)

369 CHEMISTRY teaches you to examine the air we breathe, which is often, though not very correctly, called the atmosphere, the term being derived from the Greek words *atmos*, signifying *vapour*, and *sphaira*, a *sphere* or *globe;* it is true that *air* does surround the *sphere* or *globe* of the earth; but it is *not a vapour*—it *cannot* be *condensed* into a *liquid* or *solid* state; I have already informed you of its nature, but I may here state a few more facts that it is capable of affording.

370 If you are closely shut up in a small room, why do you soon become faint and languid, and wish to throw up the window or to leave the room?

371 You will probably answer, because the room is so hot; that is one cause, certainly, but there is another, requiring a more chemical explanation.

372 After you have been closely shut up in a small room for a considerable time, the confined air does not consist of the same elements as it did when you first entered; remember you have been breathing all the time: well, the very act of breathing deprives the air of a portion of its oxygen, which element is as requisite for the support of your life as it is for the support of the flame of a candle, or of a fire; your breathing or respiration thus renders the air of the room impure or vitiated, as I shall next particularly explain.

373 Chemistry teaches you the wonderful fact,

that animal bodies contain the ultimate elements Oxygen, Hydrogen, Nitrogen, and Carbon. These elements, therefore, are present in your blood. The blood, by a miraculous adjustment of the Creator, is exposed in your lungs to the action of the air that you draw in or inhale.

374 The moment that you do so, a portion of the Carbon of the blood (which if it were kept in your body would be hurtful,) exerts affinity for the Oxygen of the air that you inhale, and instantly produces the Compound Carbonic Acid Vapour, whilst having no affinity for the Nitrogen, that Element is educed.

375 Both the Compound Carbonic Acid Vapour and the Element Nitrogen Gas are poisons; but they are thrown forth from the lungs as soon as they are produced, and educed when you exhale, and when you again inhale, a fresh portion of air enters your lungs which, in its turn, undergoes a similar change and a similar disposal.

376 In fact, then, during your breathing you are *unmixing the air,* and exhaling into the room *one poison* in the form of *vapour,* and *another* in *that of gas,* which, after a time, render the remaining *air unfit for respiration,* and you feel languid and faint, nearly as you would do if near *charcoal burning* in a brazier, in the centre of a room, for *that combustion* produces Carbonic Acid.

377 When you throw up the window sash, or open the door, you then allow the *hurtful matters* to *escape,* and *fresh air* to *enter,* by which you are again enabled to breathe freely, and if you did *not* in this manner *renew the air* of a small closely shut room, you would ultimately *swoon and die:* and such you

read in the History of England was the fate of many of our brave countrymen, who were closely shut up in a small room called the Black Hole of Calcutta.

378 Chemistry teaches the extraordinary fact, that the elements, Oxygen and Nitrogen, as they are naturally mingled in air, form the *only mixture of gases* that is fitted for the support of animal respiration; and when these elements are *artificially combined*, they *produce* no less than *five deadly compounds*.

379 Chemistry leads you to reflect with the most profound gratitude upon the surpassing goodness of the Creator, in thus ordaining the atmosphere to consist of a *definite mixture of two gases*, and in *restraining their affinities*, so that they *cannot combine*, under any changes or vicissitudes of the seasons, to produce poisons, but invariably remain *mixed* for the proper support of animal and vegetable life.

380 Chemistry teaches you that not only is your own life, and that of the whole animal kingdom dependent upon the wonderful uniformity in the nature of the atmosphere for the support of respiration, but it is equally indispensable for the support of vegetable life.

381 The poisonous exhalations from the lungs of man and animals, if permitted to remain in the atmosphere, would soon accumulate in quantity sufficient to render it hurtful to life; but the Creator has ordained the *vegetable kingdom* to exercise a miraculous influence in *removing poisonous matter from the air*, and so restoring it to its original healthful properties.

382 Before I explain to you this process of restoration, I must inform you that Chemistry teaches us to consider the ultimate elements of the vegetable kingdom to be the *same* as those of the animal kingdom—namely, Carbon, Hydrogen, Oxygen, and Nitrogen, and that *both* kingdoms *invariably* contain the element Carbon, or the *pure* combustible matter of charcoal.

383 If you place a piece of dry wood in a dull fire, you know that the wood will soon blacken, or char; this simple fact offers a question to the Chemist, namely—has the heat of the fire caused the charcoal to be made from the wood, or did the charcoal originally exist in the wood, and has the heat of the fire educed it from the wood?

384 Chemistry teaches that the Charcoal originally existed in the wood, in combination with Hydrogen and Oxygen; that the heat has disturbed the natural affinities of these elements for each other, and caused the Hydrogen and the Oxygen of the wood, and also a portion of the Oxygen of the air, to combine and produce water, at the same time that part of the carbon also combines with oxygen from the air to *produce* carbonic acid; but a great portion of the carbon (if the fire be dull) is educed, and appears in the form of charcoal.

385 From whence came the carbon into the wood during the growth of the tree that produced the wood?

386 Chemistry proves that the growing tree did not obtain carbon from the soil of the earth, nor from the water of the showers, but obtained it from the invisible atmosphere.

387 In addition to what may be called its principal constituents, the atmosphere invariably contains a portion of the vapour of water and of carbonic acid, independently of the carbonic acid which is produced during animal respiration and the burning of ordinary fuel.

388 The Creator has endowed the leaves of growing vegetables with the most miraculous power of decomposing the Carbonic Acid that may be present in the air; of so decomposing it, that the Carbon enters into the vegetable itself, whilst pure Oxygen is educed, ready to mingle with Nitrogen, and so reproduce pure air fitted for the support of animal life.

389 Chemistry teaches you how to examine the waters of the spring, the brook, the river, and the torrent, all of which yield up their secrets to reward your research; it enables you to ascertain the various metallic and saline compounds which they all contain in some degree or other; and therefore to prove how far they are suited for domestic purposes.

390 Chemistry directs your attention to the water of the ocean, instructs you how to examine the cause of its salt and bitter taste, and discovers to you the means of educing Chloride of Sodium, and Chloride of Magnesium, the *salt* taste being referrible to the former, and the *bitter* taste to the latter compound; both of which are of the utmost value in many processes of the arts.

391 Chemistry points out the composition of shells and coals, proves to you that their hardness and compactness depend upon their containing a compound of carbonic acid and oxide of calcium

(identical with common chalk); combined in some cases with an animal principle called gelatine, as being identical with *jelly;* and in others, with an animal principle called albumen, as being identical with *white of egg.*

392 From the ashes of sponges and sea-weeds, chemistry instructs you how to educe the element Iodine, which is an invaluable medicine in the hands of physicians, and of considerable use in the production of some dyes and colours.

393 Chemistry teaches you that water, in a state of absolute purity (I mean solely consisting of the elements oxygen and hydrogen), is *never* presented by nature, not even when it falls from the clouds in showers. It always contains a portion of air, which it absorbs during its fall, and then being received by the earth, and afterwards gushing forth as springs, it always contains more or less metallic compounds, derived from the soil of the earth through which it has passed.

394 Water fit for the beverage of man and animals *invariably* contains a portion of *air* and of *common salt,* and such substances are absolutely essential to the welfare of animal life.

395 Chemistry instructs you that all natural waters may be rendered absolutely pure, if required, by an artificial process, which consists in boiling the water and condensing the steam arising from it, by causing it to enter a cold receptacle; the solid impurities cannot vaporize by the heat, the actual water alone can do so; its vapour or steam condenses into drops of pure water.

396 Hence the process is called Distillation, a term

derived from the Latin *distillare*, signifying *to drop*, or *run down drop by drop*. It is one of the many useful processes contrived by the Arabian alchemists.

397 Chemistry presents instructions regarding the different methods in which water may be boiled to yield steam, and thus supplies the moving agent of that wonderful combination of mechanical science called the steam engine, an invention to the activity of which every science, art, and manufacture, is deeply indebted.

398 Chemistry affords invaluable assistance to the science of Medicine; it proves how some elements, and numerous compounds, may be employed as most powerful and efficient remedies, for the alleviation and cure of painful diseases; and, in fact, it would be extremely difficult to select any medicine which has not been presented to the physician by the science of chemistry.

399 Now I must request you to remember, that all the wonderful and important facts which I have endeavoured to explain to you regarding the objects, tendencies, and applications of the science of Chemistry, have been discovered by the *exertion* of *constant labour*, *diligence*, and *patience*.

400 Chemists are philosophers who *work*, and draw their conclusions from the results of *experiments;* and if they meet with things which they are *unable*, after all their labour, to explain, they do *not perplex* themselves by indulging in idle *speculation* or *guess-work*, but *candidly confess their ignorance*, and patiently await the time when the progress of *experiment* will enable them to acquire the *knowledge* which they so earnestly desire.

401 I must now conclude my instructions. I have endeavoured to teach you the origin, the objects, and some of the applications of Chemistry; and if you have understood my language, I think you will admit, that what I said at the beginning has proved to be true at the end, namely, that 'Chemistry is an extremely interesting and important science.'

402 I have endeavoured to facilitate your progress, by explaining the meaning and the derivation of *hard words*, many of which are not to be found in a common dictionary, and I have also endeavoured to teach you how they are *pronounced*, so far as it has been possible for me to do so without actually talking to you.

QUESTIONS FOR THE EXAMINATION OF PUPILS

CONCERNING THE

OUTLINES OF CHEMISTRY.

I. INTRODUCTION.

How many Metals were known to the Ancients?——What were the names of these Metals?——What were the Ancients supposed to know regarding some of these Metals?——Is there any proof that the Ancients knew how to do so?——Name the writer who first mentions an art by which some metals might be changed into others; state the period at which he lived.——What were the notions at that period concerning the nature of the metals that you have said were known to the Ancients?——How was it expected that Gold and Silver might be obtained from other metals, and what was the name of the substance for effecting the change?——Give me the names of the common and the precious metals, and state why they are called common and precious.——By what term was the process of changing common into precious metals denoted?——What is the derivation of the term?——The art of making the philosopher's stone, and of causing the transmutation of metals, by what term was it distinguished?——What is the derivation of that term?——Do you remember the full meaning of the term Alchemy?——Who were the first Alchemists?——From what things did they expect to force or to make the philosopher's stone, and what agent did they hope would assist them in so doing?——By what term were the contrivances and arrangements of the Alchemists denoted?——State the derivation of that term.——By what term was the apartment or building denoted in which the apparatus was placed?——State the derivation of that term.——By what term were the various operations upon materials called, and from what is that term derived?——By whom were the principles of Alchemy brought into Europe, and in what European country were they first received?——Did the principles of Alchemy remain in Spain, or did they extend to other countries?——How long was Alchemy practised?——Did the Alchemists succeed in performing Transmutation?——State what you remember concerning the two classes of Alchemists.——What remarkable circumstances regarding Alchemy happened in the reigns of Henry IV. and Henry VI.?——Do you recollect two other things that the Alchemists attempted to make, and whether they succeeded in their attempts?——When was the practice of Alchemy abandoned?——When, and with what objects, were the relics of Alchemy examined?

II. ORIGIN OF CHEMISTRY.

What was the result of the labours of the Philosophers who undertook the examination?——Write down, in English letters, the Greek word that occurs in some writings of the 11th century, and state what it was then used to denote.——From what words is the word *chemeia* supposed to be derived?——If you adopt either *chemia* or *chems* as the root of *chemeia*, and wish to express it as an English word, how do you spell such word?——If you adopt *chymos* as the root of *chemeia*, and wish to do similarly, how do you spell such word?——What is denoted by the word Chemistry or Chymistry? ——What does Chemistry teach in the first place?——Are the things called Elements the same things as are called 'the four Elements'?——What does Chemistry teach you in the second place regarding the things now called Elements?——What does Chemistry teach you in the third place regarding Compounds?——State the meaning and the derivation of the terms Primary and Secondary Compounds.——What does Chemistry teach you in the fourth, fifth, and sixth places?

III. DEFINITION OF ELEMENTS AND COMPOUNDS.

How is the Metal Lead made, or of what things does it consist? ——From what source is the Chemist bound to draw his conclusions?——Then what conclusion is he bound to draw from his experiments upon the Metal Lead?——In what sense is the term Element employed in the language of Chemistry?——What is Litharge used for; what does it look like; of what things does it consist?——You say that Litharge consists of the metal Lead and an invisible aeriform substance called Oxygen, then of what things does Oxygen consist?——By what term is the operation of discovering the elements of compounds denoted, and what is the derivation of such term?——What should you particularly remember concerning Analysis?——By what term is the operation of uniting elements to produce compounds denoted, and what is the derivation of such term?——What is the derivation of the term Litharge, and by what name is it Chemically denoted to imply its Composition?——How much Lead, and how much Oxygen by weight can be educed from 112 parts by weight of Oxide of Lead?——When the Chemist works by weight, what is he said to perform, and what if he do not work by weight?——What is White Lead used for, what is its appearance when dry, and of what things does it consist? ——How much Carbonic Acid, and how much Oxide of Lead can be educed from 134 parts by weight of White Lead?——Then what is the name of White Lead in the language of Chemistry? ——Is Carbonic Acid an element or a compound?——What is the derivation of the term Oxygen?——What is the derivation of the term Carbon?——What should you particularly remember concerning the employment of the term Oxygen?——What is the derivation of the term Gas, and what form of substances is it employed to denote?——What is the derivation of the term Vapour, and what form of substances is it employed to denote?——Give the derivation of the term condensation, and use such term in a concise answer regarding the distinction between Gas and Vapour.——What quantity of Oxygen and of Carbon, by weight, can be educed from 22 parts by weight of Carbonic Acid?——Of what things does Carbon consist, and as what does it rank in Chemistry?——What do you understand by the terms Proximate and Ultimate Elements, and from what words are the terms derived?——What are the Proximate and what are the Ultimate Elements of White Lead? ——When Elements or Compounds combine, what term is employed to denote the act of Combination, what is the derivation of such term, and its literal and figurative meaning?——How many substances can be educed by Analysis, which resist any farther Analysis, and by what title are they designated?——What do you mean by the term Ponderable Elements; state the derivation of the term, and the forms in which such elements are educed?——How many Imponderable Elements are known, and what are their names?——What conclusion does Chemistry teach you to draw from the study of the properties of the Ponderable Elements?——What contrast can you draw between Alchemy and Chemistry?

IV. ALPHABETICAL LIST OF ELEMENTS, AND PRONUNCIATION OF THEIR NAMES.

Now go through the Alphabetical List of the Elements, taking a few of the names at a time, and pronounce them as you have been instructed.

V. NATURE OF THE ELEMENTS, AND DERIVATIONS OF THEIR NAMES.

I shall now ask you questions concerning the Fifty-six Elements individually, and shall require you to give me the derivation of each of their names, where the derivation has been ascertained.——What is Aluminum, and from what is the name derived?

NOTE TO THE TEACHER.

Continue the form of the foregoing question, substituting, of course, for 'aluminum' the name of the element concerning which an answer is required, and thus proceed, throughout the Alphabetical List, from paragraph 136 *to paragraph* 190.

VI. CLASSIFICATION OF ELEMENTS.

As you have thus answered my questions regarding the names by which the elements are denoted, now tell me how most of the elements are obtained. What elements are found naturally pure or native?——How may the Elements be classified?——What are the names of the non-metallic Elementary Gases?——What are the names of the non-metallic Elementary Vapours?——What is the name of the only non-metallic Elementary Liquid?——What are the names of the non-metallic Elementary Solids?——What is the name of the only metallic Elementary Liquid?——How many solid metallic Elements are known?——Do you remember the names of the Metals, taking them in alphabetical order?——What are the most important elements; and what are the Combustible and Incombustible Elements?*——How may the 56 Elements of Chemistry be compared to the 26 letters of the English Alphabet?

VII. EDUCTION OF ELEMENTS.

What Agents are employed to discover the Elementary or Compound nature of Substances?——If one substance resist, and another yield, to the power of these Agents, how are the substances denoted? ——What Agents are preferred in Analysis, when their use is practicable?——What change does heat effect upon the solid Metal Lead?——Why does a Chemist endeavour to ascertain the cause

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*** NOTE TO THE TEACHER.—This question may be subdivided in the following manner:—What are the most important non-metallic elements?——What are the most important metallic elements?——What are the non-metallic combustible elements?——What are the non-metallic incombustible elements?——Are the metals combustible or incombustible elements?——What non-metallic element will neither itself burn, nor aid the burning of other elements?**

N.B.—The above will serve as an example how other questions may be subdivided if it be found necessary to the capacity of the pupil.

of trifling changes and appearances?——What is the meaning and the derivation of the terms Philosopher and Science?——How is the Metal Lead supposed to be kept in a solid form?——By what term is this attraction or force denoted?——Give the meaning and derivation of the terms Attraction, Aggregation, and Cohesion.——What substances are under the power of this Attraction?——There are only four conditions or mechanical states in which substances occur, what are these, and what the power of Attraction, of Aggregation, or of Cohesion in them?——When Lead is exposed to sufficient heat, how is that imponderable agent supposed to affect its Attraction of Cohesion?——When melted Lead is cooled, how is its Attraction of Cohesion effected?——What is the general effect of sufficient heat upon Lead and other Metals?——What are the two Metals that sufficient heat will change from the liquid state to that of Vapour?*——What happens if these Metallic Vapours be cooled?——Then what do you infer to be the only power of heat upon the Metals?——Give the meaning and derivation of the term Decomposition.——With what term is decomposition synonymous?——What happens when a lump of ice is placed near a fire?——What takes place if the liquid water be placed to heat on a fire?——What happens when steam is condensed into liquid water, and when this liquid water is cooled by frost?——Does the water afford any clue to its actual composition during all these changes?——Then what inference does the Chemist draw from the results of these experiments upon water?——Not having succeeded in effecting the decomposition or the analysis of water by heat, how does the Chemist next proceed to experiment?——What is the Greek name of Amber, and what English name is derived from that Greek name?——How does Electricity naturally display its extraordinary powers?

VIII. EDUCTION OF ELEMENTS—Continued.

Can the Chemist control the power of Electricity?——Some ponderable Elements and Compounds permit the passage of Heat and Electricity, others do not, or retard the passage of both imponderable elements, then by what terms are the former and the latter denoted?——Give the meaning and the derivation of the terms Conductors and Non-conductors.——Give me an example of a Conductor and a Non-conductor; or, more correctly, an imperfect Conductor of Heat.——What are the most perfect Conductors of Heat and Electricity, and what are Imperfect Conductors of these Agents?

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* NOTE TO THE TEACHER.—Some of the more scarce metals, for example, Potassium and Sodium, may be changed into Vapour.

——Why does an iron rod, attached to, or placed near, a building generally protect it from damage by lightning?——Is water a Conductor of Heat?——Then how can water be boiled when placed in a copper kettle upon a fire?——Explain the meaning and the derivation of the term Convection.——Is Water a Conductor of Electricity?——If a lightning conductor be not perfect, or continuous throughout its entire length, what generally happens to the building that it is intended to protect during a thunder-storm?——Give the meaning and the derivation of the term Disintegration? ——How does the Chemist reason upon the disintegration of building materials when the lightning strikes a faulty iron conductor?——How does the Chemist arrange water, that it may interrupt or retard the passage of Electricity from one good conductor to another?——Take your slate and pencil: write the letters A W C. Explain what I have taught you they are to denote.——What remarkable change does the water present around the platinum wires A and C?——Do these bubbles denote that the water is boiling and changing into steam?——Then what change does the Chemist infer to be taking place in the Water?——You say that the water is decomposed by Electricity, and that the bubbles of gas at A and C are educed from the water; tell me, is the gas at A of the same nature as the gas at C?——How is the difference between them experimentally proved?——What happens if the action of Electricity upon Water be prolonged for a sufficient time?——Do the Gases educed from Water admit of Analysis or Decomposition? If they be mingled in the proportions in which they were educed, and a spark of Electricity passed through the mixture, what result is obtained by such experiment?——When Electricity enters the water at A, what is the name of the elementary gas educed?——Where Electricity escapes from the water at C, what is the name of the Elementary gas educed?——State by what term the Decomposition of Water by Electricity is generally distinguished, and give the derivation of such term.——Is this Electrolysis an uncertain process?——What element is educed where Electricity enters, and what element is educed where it escapes from, water?——What are the respective quantities, by measure, of the elements educed from water?——What are the respective weights of the measures of the elements educed from water, and in what weights will they combine to produce water?——As water admits of decomposition it is no longer called an Element, then what is its true Chemical designation?——What was my object in selecting the eduction of the Elements Oxygen and Hydrogen?

IX. EDUCTION OF ELEMENTS—Continued.

What are the effects of Heat and Electricity upon the ancient element Air?——Then, as these Imponderable Agents have no power of separating Air into two or more substances, how does the Chemist endeavour to effect a separation of its principles? ——A bright iron nail is made red-hot, it soon tarnishes; what does the Chemist suspect to be the cause of its tarnishing?—— What metal will tarnish by heat more remarkably than iron?—— What result is obtained when liquid Mercury is sufficiently heated in a certain measure of confined air?——With what object did the Alchemists heat Mercury in Air, and what did they imagine to be the change sustained by that Metal?——What is the reasoning of the Chemist upon the result of heating Mercury in Air?——Is the entire measure of the original air concerned in the change of the liquid brilliant Mercury into the form of the solid red substance? ——What effect has the remaining portion of aeriform substance upon the flame of a taper?——Is the aeriform substance an element, can it be educed from another source?——Give the name of this other source; explain the meaning and the derivation of the term by which this aeriform element is denoted.——Then, by the ponderable element Mercury, under the influence of the imponderable element Heat, the Chemist has educed the ponderable gaseous element Nitrogen from Air, what does he imagine to have become of the other element of the air?——How does the Chemist proceed to analyse the red compound to educe the other element of the Air which he suspects it to contain?——Can the metal Mercury be boiled when sufficiently heated?——What happens if the red compound be heated to a greater degree than is required for boiling elementary Mercury?——You say that it is decomposed by heat, and that liquid Mercury and an aeriform substance are educed; now tell me the name of this aeriform substance.——When Nitrogen and Oxygen, the former directly and the latter indirectly, educed from Air by this analysis are mingled together, in what manner is the flame of a taper affected by such mixture?——Then what does the Chemist infer to be the true nature of Air?——In what proportions, by weight, are the Elements Nitrogen and Oxygen naturally mixed to constitute Air?——What is the nature and the correct name of the red compound produced during the experiment that you have described?——Why does the bright iron nail tarnish in the fire, and what is the correct name for denoting such tarnish?——What conclusion does the Chemist draw from the analysis of Water and of Air?——What has the Chemist proved to be the true nature of rocks, stones, and soils which constitute the ancient Element Earth?——In common with Water, Air, and Earth, Fire was anciently called an Element: tell me, does Fire merit such title?——The metallic elements which are not found naturally pure, or native, with what non-metallic elements are they usually naturally combined, and how are they educed from such combinations?——What is the process generally called?

X. WEIGHTS OF THE ELEMENTS.

Can the Chemist collect and weigh the invisible element Hydrogen? ——Does the Chemist find it to be a heavy or a light substance? ——As Hydrogen is found to be the lightest substance, by what number or word is it denoted?——What is the object of denoting Hydrogen as 1, or unity?——When I say 1, 2, 3, 4, 5, or any other number of parts, what parts do you understand that I mean?——Take your slate and pencil, write down '1 part of Hydrogen,' then the number of parts of Oxygen with which it will combine; and then the number of parts of Lead with which such Oxygen will combine.——Add the parts of Hydrogen and Oxygen together, and the parts of Oxygen and Lead together, and tell me what these sums respectively represent.——When elements combine in more than their smallest parts or weights, what is discovered regarding the additional weights?——Give an example, or examples, of this fact.——Why does the Chemist adopt the foregoing method of expressing the weights of elements and compounds, in preference to that of a per centage statement?——Take your slate and pencil, and write down the names of the elements which are of the most common occurrence, yet of the greatest importance, and write after the name of each element its smallest combining weight.——Can the Chemist produce Primary and Secondary Compounds from the union of any weights of their elements that he may choose to employ?

XI. UTILITY OF CHEMISTRY.

State the importance and utility of a knowledge of these facts regarding combination.——Can the wonders of the Creation be interpreted by the Science of Chemistry?——What does Chemistry teach you regarding the various rocks and stones of the surface of the Earth? ——What does Chemistry teach you regarding the treasures beneath the surface of the Earth?——What does Chemistry teach you regarding the Mineral called Coal?——What Compounds are produced during the burning of Coal in a common fireplace?——What is obtained when Coal is heated red-hot in an air-tight apparatus? ——How does Chemistry instruct you to produce colourless glass? ——How does Chemistry instruct you to produce coloured glass? ——Name the compounds which have the property of colouring glass.——How is colourless glass rendered valuable to the astronomer and the naturalist?——What substances does Chemistry point out as adapted for the production of white earthenware or pottery?——How are vessels of pottery rendered fit for containing water and other liquids?——What compounds are employed for colouring pottery, and for painting on porcelain?——Does Chemistry contribute assistance to the arts of dyeing and calico printing? ——What is the name of the non-metallic vapour that is educed from common Salt?——Will this Element affect dry colours?——Yet it is employed in the modern art of bleaching: state how it proves serviceable for such purpose?——Can Acids be generated without the presence of Oxygen?——If you are closely shut up in a small room, why do you soon become faint and languid? ——What change takes place in the air during the act of breathing?——What are the elements of animal bodies?——What Compound is produced, and what Element is educed, during respiration? ——Are these things hurtful or harmless?——What compound is produced during the burning of Charcoal in the air?——What would be your fate, or that of an animal, if closely shut up in a confined portion of air?

XII. UTILITY OF CHEMISTRY—Concluded.

Can any artificial mixture of gases, besides Oxygen and Nitrogen, be substituted as a medium for supporting respiration?——If the Gases which, in a state of mixture, constitute healthful air were excited to exert affinity and combine, what would be produced? ——How does Chemistry lead you to reflect with gratitude upon the goodness of the Creator of the air?——How is air which has been contaminated by the act of respiration restored to its original purity?——What are the Elements of the vegetable kingdom?——Is Charcoal produced, or educed from wood by the heat of a dull fire?——State what happens when wood is heated in a dull fire. ——From what source does a growing tree derive the Carbon that is contained in wood?——Then Air must contain other things besides the Elements Oxygen and Nitrogen: if so, what are those things?——Now state more fully how growing vegetables derive their Carbon, and restore the purity of the air.——What does Chemistry teach you regarding the waters of the spring, the brook, the river, and the torrent?——What does Chemistry pronounce to be the cause of the salt and bitter taste of the waters of the ocean? ——What does Chemistry point out regarding the structure of shells and corals?——What can Chemistry educe from the ashes of sponges and sea-weeds?——Is absolutely pure water naturally presented?——What impurity is found in rain-water, and what impurity in spring and river water?——What compound is always discovered in water that is fit for beverage?——Explain the process by which water may be obtained absolutely pure.——State the term by which such process is denoted, and give also its derivation.——How does Chemistry supply a moving agent or power for the steam-engine?——How is Chemistry of assistance to Medicine?——How have all the foregoing facts been discovered?

THE END.

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